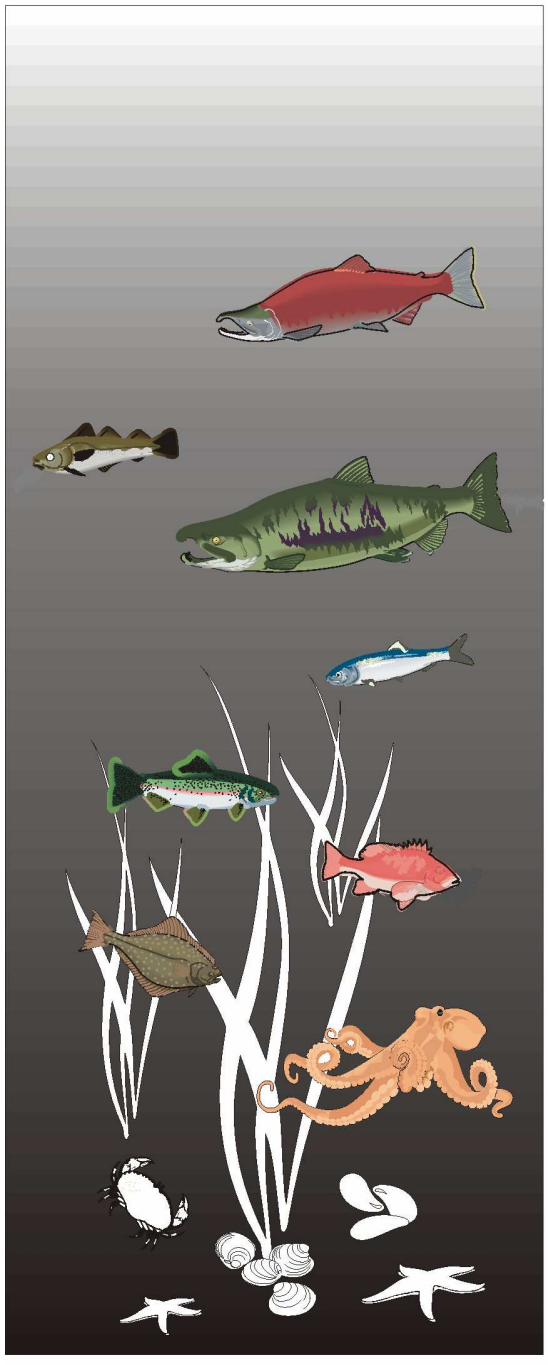
Northwest Fishery Resource Bulletin



Coho Salmon Escapement to the Skagit River Estimated Using a Mark-Recapture Method: 1990

By

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Project Report Series No. 11

Northwest Fishery Resource Bulletin

Project Report Series

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ABSTRACT

Since 1965, an index live-count method has been used to annually estimate the number of coho salmon in the escapement to the Skagit River. The accuracy and precision of the estimates from this method have never been critically examined. A five-year project to examine alternative methods of estimating the number of wild coho salmon in the escapement to the Skagit River was begun in 1986. In addition to the index live-count method, three other methods of estimating the coho salmon escapement to the Skagit River were examined: (1) a mark-recapture method; (2) a redd-count expansion method; and (3) a method based on estimates of the proportional contribution of hatchery-produced coho salmon to the total escapement. **This report documents the results of the mark-recapture portion of the project for 1990.**

In 1990, coho salmon were captured with a beach seine at river mile 35 near the town of Lyman on the Skagit River from 7 September through 7 November. A total of 670 coho salmon were tagged with a jaw tag and marked with opercula punches. Tags were recovered during surveys designed to randomly sample the coho salmon escapement. Tag recovery samples were collected at 13 areas in the Skagit River drainage: Marblemount Hatchery; Baker River trap; spawning grounds in the Middle Skagit, Upper Skagit, Lower Sauk, Middle Sauk, Upper Sauk, Suiattle, Cascade, Nookachamps, and Carpenter sub-basins; and in commercial or test fisheries. In total, 15,478 coho salmon were examined of which 15,303 fish were considered in-sample and 175 were not considered part of the population subject to tagging.

A total of 154 tagged or marked coho salmon were recovered during in-sample surveys. The tag recovery data indicate that approximately 1.5% of the coho salmon migrating through the lower Skagit River tagging area were caught and tagged. About 1.5% of the coho salmon returning to Marblemount Hatchery and 1.2% of the coho salmon returning to Baker River trap were tagged. About 1.5% of the fish in the combined samples from all spawning grounds above the tagging area were tagged. The tag recovery data indicate that some coho salmon from spawning areas downstream of the tagging site were present in the tagging area. There were three tags recovered in 4,733 coho salmon examined (0.1%) during sampling of downstream areas.

The estimated abundance of coho salmon in 1990 was 47,064 fish with a 95% confidence interval of 40,507 to 56,955 fish. This estimate is for the number of coho salmon migrating through the tagging area after tagging began on 7 September. It includes all coho salmon bound for spawning areas above the tagging area and an unknown fraction of the salmon from spawning areas in the Nookachamps and Carpenter sub-basins. This abundance estimate was very precise (CV = 7.6%) because of the large number of fish examined for tags during in-sample surveys. To restrict the estimate to spawning areas in the Middle Skagit sub-basin and spawning areas above it, “adjustments” were made to the number of tags released. Using the adjusted number of tags released, the estimated abundance for this more restricted area was 46,433 coho salmon. **The total return of coho salmon to Skagit Bay in 1990 is estimated to be 60,444 fish. There were an estimated 38,914 naturally-spawning coho salmon in the escapement to Skagit River spawning grounds**: 37,574 fish were estimated to have reached upstream spawning grounds and 1,340 coho salmon were estimated for lower river (Nookachamps and Carpenter sub-basins) spawning grounds (see summary table on the next page).

Table summarizing the total return of coho salmon to Skagit Bay in 1990 by its major components.

Component	Number of Fish
Total Terminal Run Size	60,444
Marblemount Hatchery	7,329
Baker River Hatchery	629
Commercial Fishery Catches	11,944
Test Fishery Catches	1,628
Subtotal	21,530
Wild Escapement	
Upstream Areas	37,574
Lower Areas	1,340
Subtotal	38,914
Sport Catch[a]	497

[a] An unknown portion of the sport catch should be subtracted from the wild escapement and the remainder added to the total terminal run size.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

INTRODUCTION

The Skagit River is the largest river system in the Puget Sound region. It has 162 miles of mainstem river and its headwaters are in Canada (Figure 1). This system is one of the largest producers of coho salmon (*Oncorhynchus kisutch*) in northern Puget Sound. Coho salmon from the Skagit River are caught in fisheries from Northern California to Southeast Alaska and are a major contributor to fisheries in the inside marine waters of Georgia Strait and Puget Sound (PFMC 1992). The Skagit River is managed for natural production of coho salmon (subsequently referred to as wild coho salmon). In years when the numbers of wild coho salmon projected to return to the Skagit River are small, fisheries from Cape Falcon, Oregon to the US/Canada border have been constrained to protect these fish (PFMC 1986, pg. III-9; and PFMC 1988, pg. III-11). Accurate annual assessments of stock status are required for coho salmon from the Skagit River because this stock can affect the management of fisheries over such a large geographic area. This ensures that fisheries are not unnecessarily restricted during years when there is not a conservation problem and prevents over-harvest of wild coho salmon from the Skagit River during years of small returns. An important component of the information needed to accurately assess the status of wild coho salmon from the Skagit River is an annual estimate of the number of coho salmon in the spawning escapement. Spawning escapement, as used in this report, refers to the number of adult coho salmon which are present in all natural spawning areas of the Skagit River and have the potential to spawn in these areas. It does not include coho salmon returning to Marblemount Hatchery or to the release site for hatchery-produced coho salmon at the Baker River dam.

Since 1965, the Washington Department of Fish and Wildlife (WDFW) has used an index live-count method to annually estimate the escapement of coho salmon to the Skagit River (Flint 1983). The accuracy and precision of the estimates from this method have not been critically examined. A five-year project to examine alternative methods of estimating the number of wild coho salmon in the spawning escapement to the Skagit River was begun in 1986. This project was conducted by the Skagit System Cooperative (SSC) in cooperation with personnel from WDFW and Puget Power and Light. Three methods of estimating the spawning escapement of coho salmon to the Skagit River were examined: (1) a mark-recapture method; (2) a redd-count method; and (3) a method based on estimates of the proportional contribution of hatchery-produced coho salmon to the total escapement.

This report is the fifth in a series of reports that documents the studies conducted from 1986 through 1990 which examined different methods for estimating the escapement of coho salmon to the Skagit River. The 1986, 1987, 1988, and 1989 studies are summarized, respectively, in Conrad et al. (1997, 1998a, 1998b, 1998c). **This report summarizes the data and documents the results of the mark-recapture portion of the project for <u>1990</u>.** Reports documenting the results of the other methods of estimation will follow. Some summary data from the other years of the study are used to support some of the assumptions required for the analysis of the tagging data from 1990. These data are documented in Conrad et al. (1997).

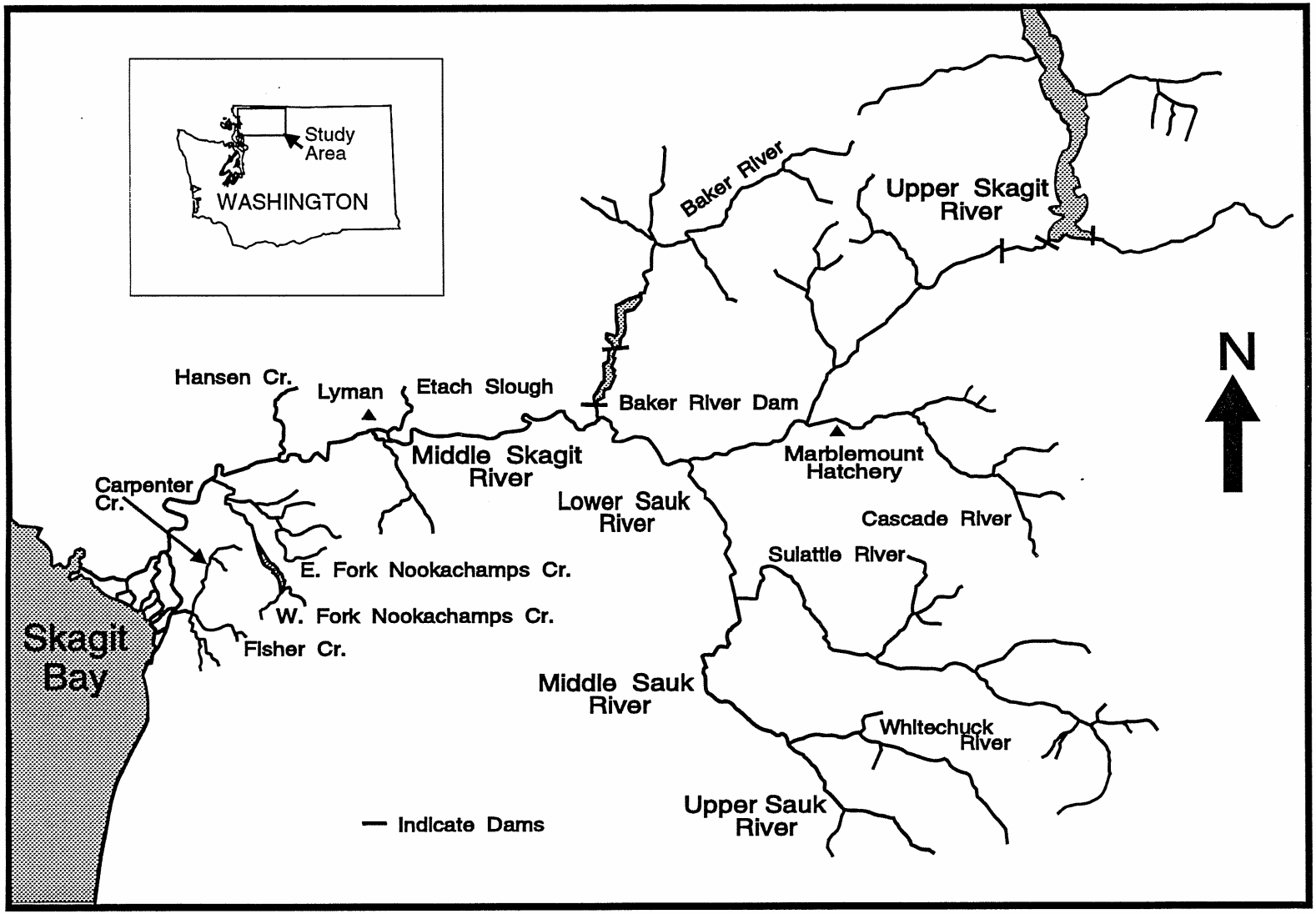

Figure 1. Map of the Skagit River system showing the location of the areas where tag recovery surveys were conducted.

METHODS

The description of methods is divided into four sections. The first section describes the methods used to capture coho salmon for tagging and the tagging procedure. The second section describes the surveys used to recover tags. This includes a description of the survey procedures for each of the tag recovery areas. Section three summarizes the statistical procedures used to estimate the abundance of coho salmon from the tag release-and-recovery data. The last section describes some miscellaneous analyses conducted to examine migration timing and the sex and length composition of the coho salmon that were sampled.

Tagging Methods

Beach Seining:

Coho salmon were captured for tagging using a beach seine operated by a five-man crew. Seining was conducted primarily at a single site at about RM 35 near the town of Lyman on the Skagit River (Figure 2)[1]. A beach seine that was 456′ long by 20′ deep was used to capture coho salmon. The seine had two wings: one was 90′ long and made of 3.5″ knotless nylon and the other was 330′ long and made of 2.75″ monofilament. The net had a 36′ bunt made of 2″ knotless seine material. Cork spacing was 8″ on the bunt and two feet on the rest of the net. The leadline was hung with 15 lb per 60′ of net. Modifications in net dimensions occurred whenever the seine was damaged. Due to heavy use, the leadline was rehung about every four fishing days and the monofilament was replaced after every eight to ten fishing days.

A boat was used to set the beach seine. One end of the seine was held by two crew members on a gravel bar while the boat backed away from the shore and the net was set off the bow of the boat. When the entire net was out, the boat-end of the net was towed downstream. The other end of the net was attached to a four-wheel drive truck and driven slowly downstream. Care was taken to prevent the shore-end of the net from getting ahead of the boat because fish tended to lead away from the shore and around the boat. During the drift, a seine plunger (a long pole with a cup on the end) was slammed into the water periodically to drive fish away from the river-end of the net and toward the shore. At a pre-designated point the boat returned to the gravel bar. Upon reaching the shore, the boat-end of the net was attached to the back of a second four-wheel drive truck. Both trucks then pulled the net up the gravel bar, perpendicular to the river, until only the bunt end of the net was in the water. The five-man crew then pulled the bunt in by hand until the leadline was on shore while the cork line and ends were cradled by the crew.

[1] One coho salmon was tagged on October 30, 1999 at a nearby drift net site.

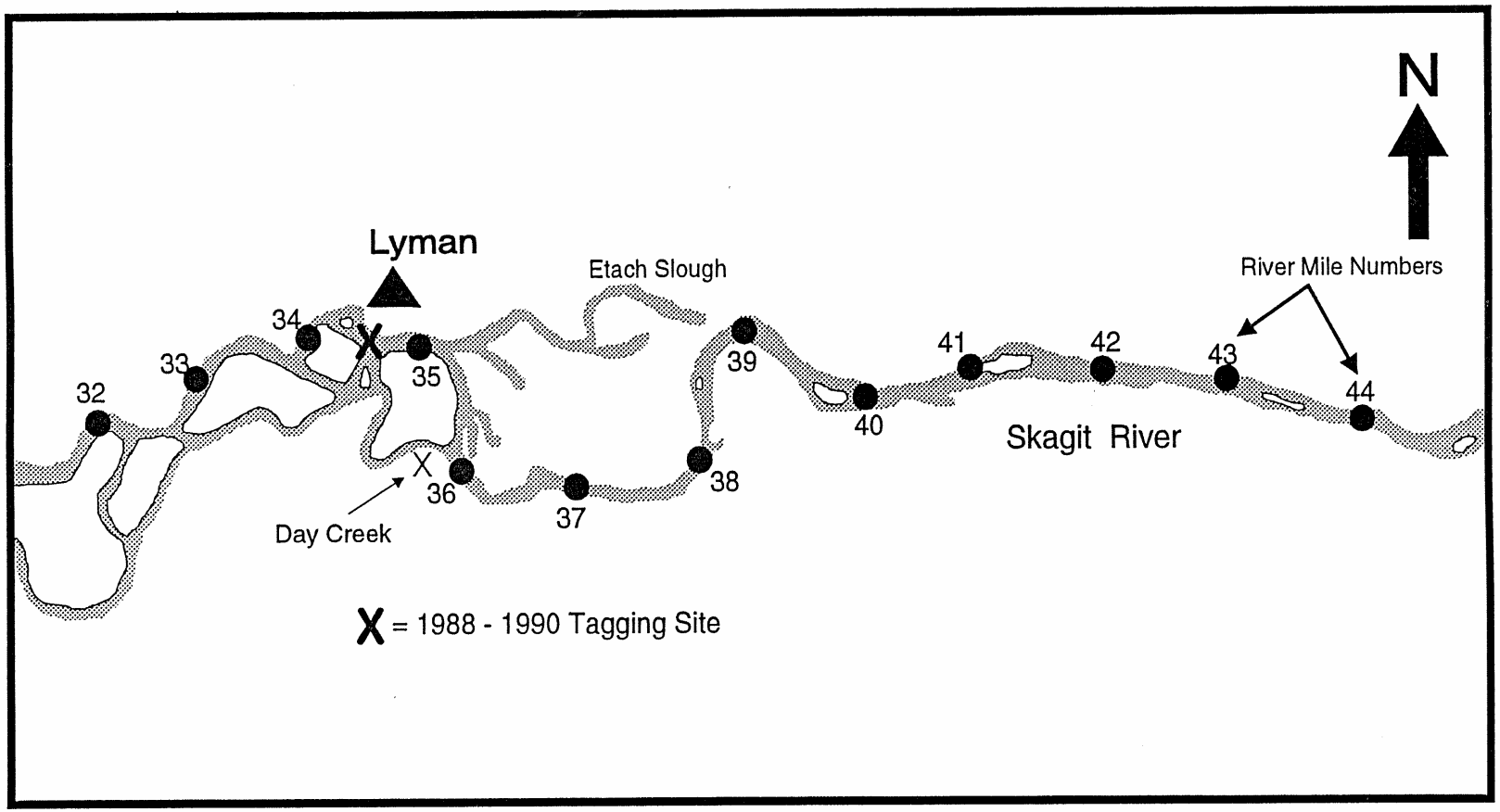

Figure 2. Map of the area of the Skagit River where coho salmon were captured and tagged, 1986-1990.

Tagging Procedures:

Coho salmon were removed from the bunt and placed into either of two net pens adjacent to the capture site. All other species were counted and returned to the river. The pens were 3′ by 5′ by 5′, constructed of PVC, and covered with 0.5″ knotless nylon mesh. Each coho salmon was taken from a net pen by a sampler wearing cotton gloves and placed on a V-shaped measuring board lined with high-density foam. A sequentially-numbered hog ring was clamped around the lower left mandible of each fish using a pair of hog-ring pliers and a 3/8″ hole was punched in the rear center of each gill operculum with a paper hole-puncher. From 7 September through 19 October, yellow bands were used on the hog rings; from 24 October through 7 November red bands were used. The fork length (measured to the nearest cm), sex of the fish, any external marks, and a qualitative assessment of maturity (bright, blush, or dark) were recorded for each fish with the date and tag number. Each tagged salmon was held gently in the water until its equilibrium was regained before being released. If a tagged fish did not swim away or appeared to be injured it was given a condition rating of "X-". Fish that swam away normally were given a condition rating of "X". Fish with severe physical impairments (e.g., 50% scale loss, torn opercula, deep predator wounds) were released untagged. These included jack coho salmon (male salmon under 30 cm in length) which generally gilled in the net and were unfit for tagging.

Tag Recovery Surveys

Only tags recovered during surveys designed to randomly sample the coho salmon escapement were used for the abundance estimates. These are referred to as **in-sample recoveries**. Tag recovery surveys were conducted by sampling: (1) all fish spawned, surplused, or otherwise sacrificed at Marblemount Hatchery; (2) all fish caught at the fish trap at Baker River dam; (3) the catch by the in-river commercial fishery; (4) all test fishery catches; (5) every reachable and identifiable dead coho salmon found during spawning grounds surveys; and (6) every coho salmon caught in traps operated on: Carpenter Creek Slough (a tributary to Carpenter Creek) and Etach Slough (a tributary to the Middle Skagit sub-basin). During each survey or day of trap operation, the date, number of coho salmon inspected for tags, number of tagged or marked (with the opercula punches) fish found, and tag numbers of all coho salmon recovered with legible jaw tags were recorded.

Marblemount Hatchery:

Samples were collected by four different methods at WDFW's Marblemount Hatchery in 1990: spawned fish, surplused fish, pond mortalities, and above-rack recoveries. After any processing, hatchery personnel sorted fish from the first three groups into separate bins for tagged/marked and unmarked fish. SSC crews then re-checked these bins for coho salmon with tags or marks. Due to flooding at the hatchery in 1990, some coho salmon which had entered the hatchery escaped to feeder ponds above the hatchery. These fish were sampled using beach seines and are referred to as above-rack samples. The date of sampling, number of coho salmon inspected for tags, number of tagged or marked fish found, and tag numbers of all coho salmon recovered with legible jaw tags were recorded.

Coho salmon were spawned at Marblemount Hatchery to meet specific egg-take goals. Spawning was conducted when the portion of the run from which eggs were desired was present and there were large numbers of fish in the holding ponds. Hatchery personnel selected fish for spawning and sorted them into the bins after spawning for SSC crews to examine. Surplused fish were those in excess of the spawners needed for eggs. Surplus coho salmon were periodically sacrificed and sorted into the bins. The holding pond was periodically surveyed for mortalities and any dead coho salmon were removed and sorted into the bins. A schematic of the Marblemount Hatchery sampling procedure is shown in Figure 3.

Except for the pond mortalities, hatchery personnel selected the coho salmon for the other two groups, spawned and surplused, according to a visual assessment of the fish and the timing of the return to Marblemount Hatchery. Therefore, these fish were not strictly sampled at random and the percentage of tagged fish in these samples might have been influenced by the selection process. However, since all coho salmon returning to the hatchery were sampled, the Marblemount Hatchery sample was a census and the sample total for the entire spawning season provided the best estimate of the percentage of tagged coho salmon at Marblemount Hatchery.

Baker River Trap:

A fish trap at Baker River dam caught all upstream migrating salmon. All coho salmon caught at the trap were examined. Fish caught in the trap were crowded into a brail and several removed at a time onto a sorting table. Each coho salmon was examined for a tag or mark. The sample date, condition, and tag number (when legible) were recorded for any jaw-tagged or opercula-punched coho salmon. After all live fish in the brail were removed, the racks and screen of the trap were searched for dead fish. Therefore, identically to the Marblemount Hatchery sample, the Baker River trap sample was a census and the sample total for the entire spawning season provided the best estimate of the percentage of tagged coho salmon at the Baker River trap.

The Baker River stock is one of the earliest returning coho salmon stocks to the Skagit River. Coho salmon were counted at the Baker River trap before tagging was begun in the lower river during two years of the study. In the other years of the study, coho salmon were counted at the trap so soon after tagging was initiated that we assumed some fish had migrated past the tagging site before tagging had begun and, therefore, were not subject to capture. Since these early-arriving fish were not subject to tagging, we excluded them from the number of fish examined for tags that was used for the population estimates (i.e., they were not considered in-sample). We examined the number of days between release and recapture for all coho salmon recovered at the Baker River trap during the five years of tagging. The minimum travel time (number of days between being tagged and released in the lower river and recovered at Baker River trap) observed during the study years was four days (Conrad et al. 1997). Therefore, all fish counted at the Baker River trap prior to four days after tagging had begun were excluded from the in-sample survey.

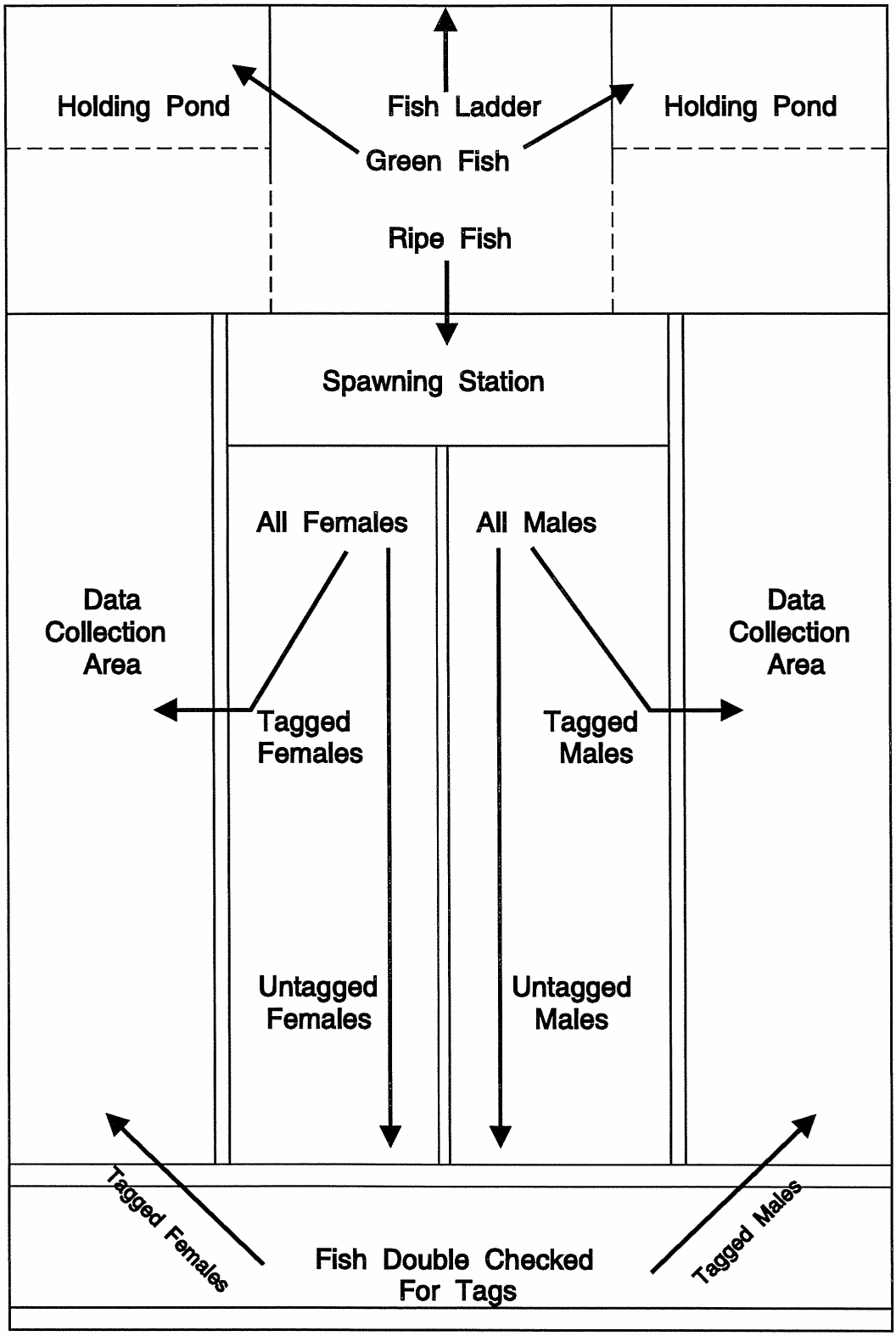

Figure 3. Schematic of the sampling procedure used to process coho salmon for tag examination at Marblemount Hatchery.

In-River Commercial and Test Fisheries:

Tag recovery samples from the commercial catch were collected in conjunction with routine commercial catch sampling activities. The Skagit River is divided into statistical areas for commercial catch regulation (Figure 4). To allow tag recovery samples from the catch to be analyzed by area of capture, all major salmon buyers were instructed to place catches from each statistical area into separate bins. This occurred during all salmon fisheries in the upper Skagit River during 1990. In 1990, most samples were allocated to sub-areas (78D-2, 78D-3, etc.) within Area 78D. When the sub-area was not known (i.e., the sample was labeled "Area 78D"), we assigned the sample to the upstream areas (78D-3 or 78D-4) for population analyses. Three samples were labeled "Area 78D-2&3"; we assigned these samples entirely to Area 78D-2.

A test fishery was conducted by a crew from Skagit System Cooperative to provide an in-season assessment of the size of the coho salmon run. In 1990, test fisheries were conducted in: Area 2; Spudhouse; Blakes; and Jetty in Skagit Bay (Figure 4). Drift and set gill nets used at the test fish sites had mesh sizes ranging from 5″ to 6″. Hayman (1996) describes the test fishing procedures in detail. All coho salmon caught during the test fishery were inspected for tags or marks.

Both WDFW and tribal commercial catch and hatchery samplers in areas outside of the Skagit River were notified to look for jaw tags from the Skagit River study. These recoveries allowed us to assess the degree of out-of-system straying by coho salmon tagged in the mainstem of the Skagit River.

Spawning Grounds:

Tag recovery surveys of the spawning grounds were conducted in conjunction with surveys to estimate the coho salmon escapement using redd counts (Conrad et al. 1993). For the redd-count method, the Skagit River system was stratified into the nine sub-basins listed by Johnson (1986): Carpenter; Nookachamps; Middle Skagit; Upper Skagit; Lower Sauk; Middle Sauk; Upper Sauk; Suiattle; and Cascade (Figure 1). Stream sections in each sub-basin were surveyed from one to 11 times during the spawning period for coho salmon. In 1990, about 16% of the total length of potential spawning habitat in the Skagit River was surveyed (Conrad et al. 1993). During spawning ground surveys, any coho salmon carcasses observed were sampled for jaw tags and opercula marks. Gill opercula of untagged carcasses were carefully inspected for marks or healed marks. A healed (regenerated) mark was evident as a perfectly round discoloration on the gill cover that was lighter in color than the surrounding opercular tissue. Occasionally a carcass could not be sampled because of a missing head due to advanced decomposition or removal by predators. Unsampled carcasses were tallied during each survey. The date, survey location, number of coho salmon carcasses sampled, number of tagged or marked fish recovered, and tag numbers of all coho salmon recovered with legible jaw tags were recorded during these surveys. The caudal fin of all sampled carcasses was removed to prevent the carcass from being sampled again.

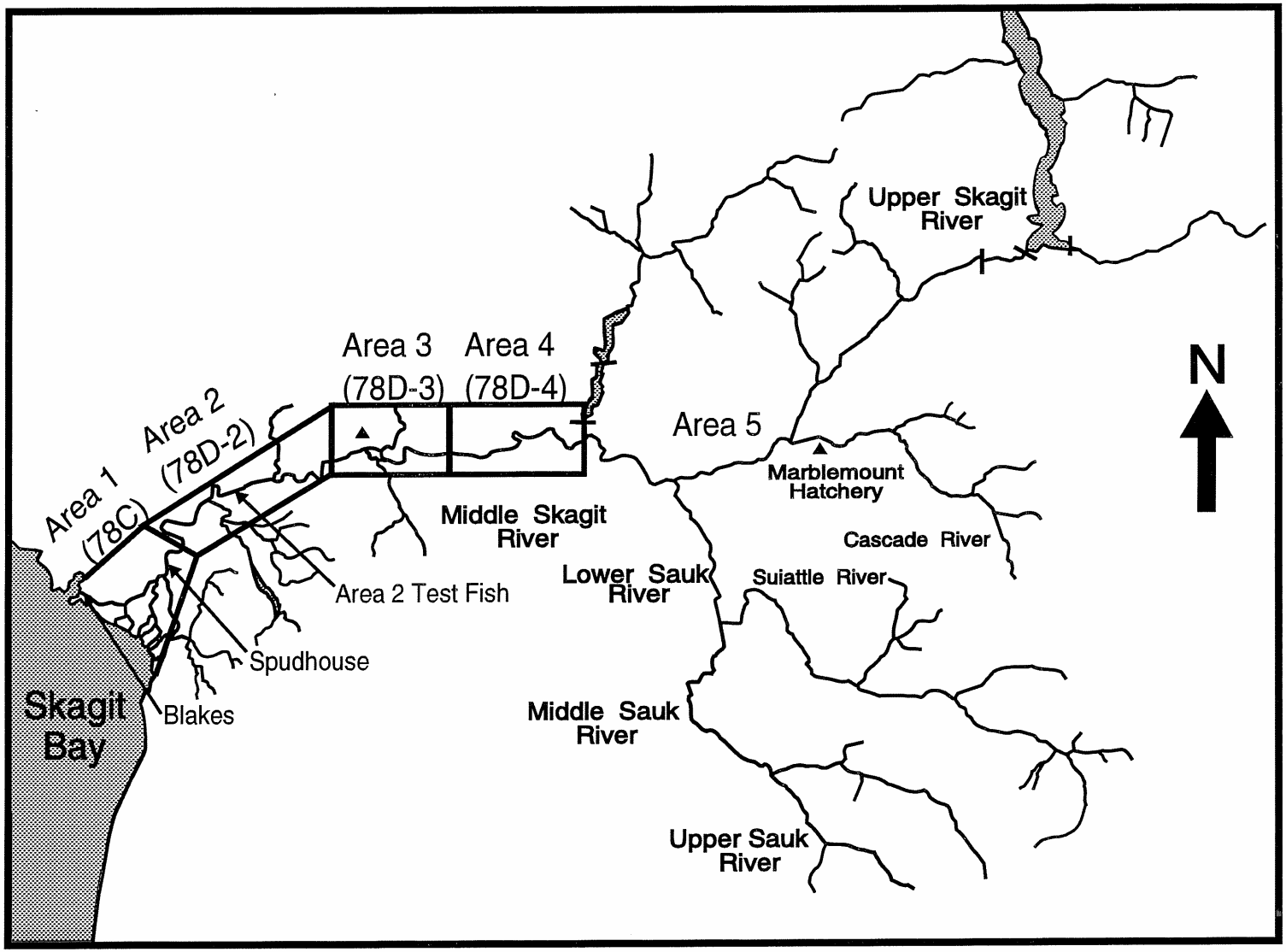

Figure 4. Commercial fishery areas of the Skagit River as designated by WDFW.

Tributary Traps:

SSC operated traps on Carpenter Creek Slough (a tributary to the Carpenter sub-basin) and Etach (or Red Cabin) Slough (a tributary to the Middle Skagit sub-basin) in 1990. Both traps were wooden weirs that blocked the entire creek and funneled fish into a live box. Traps were located in areas that had easy accessibility, a section of relatively straight stream channel with a low gradient, and a stable substrate.

All traps were checked and cleaned at least twice daily. A knotless-nylon dip net was used to move the trapped coho salmon into a 30-gallon plastic container filled with water. All coho salmon caught were examined for tags or marks and then released upstream. A Petersen disk tag and a unique operculum punch (i.e., a punch pattern different from that used in the main-river tagging) were placed on all coho salmon released above the traps. The trap crews also recovered tags at the weirs from spawned-out carcasses which had washed downstream from the spawning areas (called rack recoveries). The caudal fin was cut off all rack recoveries. The date, number of coho salmon sampled, number of tagged or marked fish recovered, and tag numbers of all coho salmon recovered with legible jaw tags were recorded.

Abundance Estimates

Two different mark-recapture models were considered for estimating the number of coho salmon which migrated through the tagging area in the lower Skagit River, the Petersen estimation model and Darroch's stratified estimation model. When tagging and recovery occur over an extended time period, such as occurred in this study, it is not uncommon to observe temporal changes in: (1) the probability of capture of fish in the target population; and/or (2) the probability of finding a tagged fish during tag recovery surveys. When such changes occur the Petersen model is often not the appropriate estimation model. Seber (1982) describes a series of χ^2 tests to determine whether the data are consistent with a Petersen estimate. Specifically, the tests determine whether the data are consistent with the following four conditions: (1) there was uniform recovery of tags across the tag recovery strata; (2) there was uniform tagging across the tag release strata; (3) there was complete mixing of the population between tagging and recovery; and (4) the expected number of tags recovered in each stratum was proportional to the number of unmarked individuals present.

Eames et al. (1981, 1983) describe the exact form of these tests for a study similar to ours in both the study design and estimation procedures. They captured chum and coho salmon in marine areas immediately in front of the mouths of major river systems in Puget Sound and tagged the fish with jaw tags. Tags were recovered during surveys of spawning grounds throughout these river systems. We followed procedures similar to those described by Eames et al. (1981, 1983) to determine the appropriate estimation model.

Petersen Estimation Model:

The simplest and most commonly used model for estimating abundance from mark-recapture data is the Petersen model. Conrad et al. (1997) discuss the necessary assumptions for the Petersen model as implemented for this study.

Robson and Regier (1964) recommend that a Petersen estimate include a minimum of seven tag recaptures to ensure that the bias of the estimate is negligible. Therefore, we estimated abundance from the tagging data only when there were at least seven recaptures of tagged or marked coho salmon from a recovery area. Chapman's unbiased form of the Petersen estimate (Seber 1982) was used to estimate abundance. Conrad et al. (1997) describe the model and the procedures used to estimate 95% confidence intervals. For any Petersen-type estimator (including Darroch's stratified estimator), the abundance estimate depends upon ρ, the proportion of the population tagged. The proportion of tags in the second (recovery) sample provides an estimate of ρ. Generally, as $\hat{\rho}$ becomes smaller the estimated abundance becomes larger for a given number of tags released.

Darroch's Stratified Estimation Model:

Darroch (1961) developed a stratified population model for open populations that is not predicated on constant probabilities of capture or recovery. The necessary assumptions for this model are discussed in Seber (1982) and summarized by Conrad et al. (1997). Conrad et al. (1997) also describe the model and its application to the tag release-and-recovery data collected for this study.

Definition of Strata:

Two different tag recovery percentages were examined to help define tag release and tag recovery strata. To determine if the probability of finding a tagged fish in recovery samples was different among recovery locations or among different time periods at the same location, the percentages of tags in recovery samples (ρ as defined previously) were compared. The percentages of tags recovered from releases during specific time strata, π, were compared to determine if there were differences in the probability of recovering fish tagged during different segments of the release period. For these tests it was necessary to define temporal strata for both the tag release data and the tag recovery data from each recovery area.

Tag release strata were established by dividing the release data into four to six strata with about an equal number of days of tagging in each stratum. The percentages of tagged fish recovered from each release stratum (π) were compared using χ^2 tests to determine if they were equal. If a significant difference was found ($P \leq 0.10$), additional χ^2 tests were conducted to more precisely define the release strata by pooling adjacent strata which did not have significantly different π.

Three different criteria were used to establish tag recovery strata: (1) number of days of sampling; (2) number of tags recovered; and (3) number of fish examined for tags. Initially, two recovery strata were defined by dividing the data so there were approximately equal numbers of the criteria (days surveyed, number of tags, or number of fish examined) in each stratum. The percentages of tagged fish in each recovery stratum (ρ) were tested to determine if they were equal among recovery strata for each stratification criteria. If a significant difference was found ($P \leq 0.10$) additional χ^2 tests were conducted within the initial strata to more precisely define the recovery strata.

Testing ρ and π:

Tests were conducted to determine if there were significant differences in tag recovery percentages (either ρ or π) between different samples or groups of fish (e.g., between surveys conducted by SSC and WDFW, or between samples collected during different time periods, or between samples collected at different locations, or between male and female coho salmon). When the expected number of tag recoveries for each group in a comparison was five or greater, a standard χ^2 test (Conover 1980) was used to test for differences in tag recovery percentages (ρ or π). If the number of tag recoveries was insufficient for a χ^2 test (one or more cells with expected frequencies less than five) and there were only two release strata or recovery locations to compare, Fisher's exact test (Conover 1980) was used. Otherwise, an approximate randomization test (ART) was conducted (Noreen 1989). An approximate randomization test is a computer-intensive method of testing whether the data in a contingency table are similar. It is similar to Fisher's exact test but uses a computer to repeatedly resample the data and approximately estimate the probability of observing the configuration of the data in the table (under the null hypothesis that the samples are from the same population).

Selection of Estimation Models:

If we assume that coho salmon bound for each recovery area are randomly sampled as they migrate through the lower river tagging area, the recovery data (number of tagged or marked fish found and number of fish examined) from each recovery area can be used to estimate ρ, the percentage of the population that was tagged. If the hypothesis of equal $\hat{\rho}$ among recovery areas was not rejected ($P > 0.10$), the tag recovery data from the different areas were pooled. The pooled data were then used in the tests to determine if the tag release-and-recovery data were consistent with the Petersen model. We feel that the variation in $\hat{\rho}$ among the recovery areas generally reflects sampling variation in the recovery areas. The number of carcasses examined for tags was relatively small for some recovery areas. In some cases, all samples were collected from a relatively discrete area within the general recovery area which could influence the proportion of tagged carcasses present. Generally, the areas with greatly different recovery percentages (more than a 0.5% difference from the major recovery areas) had less than seven tag recoveries each.

The different population estimates that were generated using the data from different recovery areas (or pooled recovery areas) were usually not significantly different from each other. Therefore, we selected the estimate with the smallest coefficient of variation as the "best" estimate of abundance for each year.

The model used to estimate abundance, simple Petersen or Darroch's stratified, was determined by the results of the tests for the consistency of the data. The four χ^2 tests used to determine consistency are described by Seber (1982) and by Eames et al. (1981, 1983).

Allocating Marked-Only Fish to Release Strata:

From 12% to 24% of the in-sample recoveries each year had a tag with an illegible number or had no tag and were identified as tagged fish by the opercula punches. The release stratum for these fish was unknown and had to be estimated for the stratified estimator. Marked fish with missing or illegible tags were allocated to release strata within a recovery area based on the proportional distribution of legible tags from each release stratum (Conrad et al. 1997). This assumes that tag loss or tag illegibility is a random process and that coho salmon tagged during each release stratum have equal rates of tag loss, therefore, fish with missing or illegible tags are assumed to have a similar distribution for stratum of release as fish with legible tags. If tag loss (or a tag becoming illegible) is a time dependent process, then fish tagged during the earlier release strata might be expected to have higher rates of tag loss and this assumption would not be true. Eames et al. (1981, 1983) used procedures similar to ours to allocate fish recovered with missing tags to release strata in their study. Errors in the assignment of marked-only fish to release strata affect only the Darroch estimate.

Additional Analyses

Several additional analyses of the data collected during tagging and tag recovery surveys were conducted. These included analyses to determine the timing of the migration of different spawning groups through the tagging area and analyses of sex and length composition data. These analyses were not required for the abundance estimates but were conducted to describe the characteristics of the annual return of coho salmon to the Skagit River during the study years.

Migratory Timing to Major Recovery Areas:

The timing of coho salmon migrating through the lower river tagging area was estimated from an analysis of the release dates of the tags recovered in each major recovery area (excluding commercial and test fisheries). Only areas with ten or more legible tag recoveries were included in the analyses. Ten, 10-day time periods were defined for the migratory timing calculations: (1) 1 September to 10 September; (2) 11 September to 20 September; (3) 21 September to 30 September; (4) 1 October to 10 October; (5) 11 October to 20 October; (6) 21 October to 30 October; (7) 31 October to 9 November; (8) 10 November to 19 November; (9) 20 November to 29 November; and (10) 30 November to 9 December.

Catch-per-unit effort (CPUE) by the beach seine used to capture coho salmon for tagging was used to describe the timing of the run through the tagging area in the lower river. CPUE was calculated for each 10-day period as the total number of coho salmon caught divided by the total number of beach seine sets (catch per set). The number of tags recovered in each major recovery area from each of the release periods was used to estimate the CPUE of coho salmon bound for these areas. The CPUE of coho salmon from recovery area *j* during release period *i* was estimated by:

$$\hat{\omega}_{ij} = \frac{r_{ij}}{f_i} \qquad [1]$$

where $\hat{\omega}_{ij}$ = the estimated CPUE of coho salmon from recovery area *j* during release period *i*,

r_{ij} = the number of tags recovered in area *j* that were released during period *i*, and

f_i = the number of beach seine sets made during period *i*.

For each area analyzed, the CPUE estimated for each 10-day period was summed across all ten time periods to estimate a season total CPUE of coho salmon bound for that recovery area. The estimated CPUE of coho salmon from recovery area *j* during time period *i* was converted to the percentage of this season total CPUE for recovery area *j* to describe migratory timing (Mundy 1982). These data were then graphed so that the migratory timing patterns for the major recovery areas could be compared.

Analyses of Sex and Length Composition Data:

Significant differences in the probability of recovering coho salmon tagged during different release periods (π) were found at some recovery locations in 1990. Temporal trends in the probability of recovery could be due to changing environmental conditions at the tagging site which influenced the probability of capture. For example, high and low water conditions may have influenced the effectiveness of the beach seine used to capture fish in the tagging area. Under low water conditions a higher proportion of the coho salmon present might have been caught than under high water conditions. Another possible explanation is that physical characteristics of the fish themselves (for example, sex or length) may influence both rate of capture for tagging and rate of recovery in tag recovery samples. For example, the beach seine may capture larger coho salmon at a higher rate than smaller coho salmon so that a higher proportion of the larger fish were tagged. As long as there is random mixing of coho salmon tagged during different time periods in the recovery areas, and the recovery process does not have the same selectivity as the capture process, this presents no problems for the abundance estimates.

Significant differences in the probability of finding a tag during surveys conducted at different times in a recovery area (ρ) were often found. Temporal trends in the physical characteristics of the population, combined with temporal trends in capture efficiency at the tagging site, could cause the changes observed. During spawning ground surveys, male fish may be more likely to end up in locations that are sampled than female fish, or larger fish may have a higher

probability of being seen and sampled during spawning ground surveys than smaller fish. The available data were examined to determine if these influences were present. The data used in these analyses were the length and sex composition data for all coho salmon tagged at the lower river tagging site and the tag recovery data used for the population estimates. Coho salmon recovered with a missing or illegible tag but having an operculum punch could not be used since their length and sex were not recorded at time of recovery.

Seber (1982) recommends testing the release (tagging) and recovery (escapement) samples for randomness with respect to length of the individual fish. The recovery sample was tested by comparing the length distributions of individuals that were tagged but not recovered to those individuals that were tagged and recovered. Both a Mann-Whitney U test and a Kolmogorov-Smirnov (K-S) test (Conover 1980) were used to compare the length distributions of coho salmon from these two groups. These same tests were also used to compare the length distributions of male and female coho salmon that were tagged in the lower Skagit River.

If there was a significant difference between the length distributions of male and female coho salmon subsequent analyses were conducted for each sex separately. If there was a significant difference between the length distributions of coho salmon which were tagged but not recovered and those that were tagged and recovered, K-S tests were performed sequentially on the length distributions to determine length categories with no significant difference between these two groups. Testing began between 65 and 70 cm (above which the length distributions of the two groups were not significantly different) and length was sequentially decreased by one cm intervals until a significant difference ($P \leq 0.05$) between the groups was found. A K-S test was then performed on those fish that were at the length of the significant difference or smaller. If there was a significant difference between the fish which were tagged but not recovered and those that were tagged and recovered the process was repeated for the fish in this smaller length range.

RESULTS

The results of the tagging conducted in 1990 are summarized in the following five sections. The summary consists of: (1) tag releases by day; (2) tag recoveries by location; (3) abundance estimates produced using the tag release-and-recovery data; (4) additional analyses which include migratory timing information from the release-and-recovery data and sex-length composition data; and (5) a discussion of the "best" estimate of the number of coho salmon migrating through the tagging area in the lower Skagit River.

There are two different tag recovery percentages presented in the results; the percentage of tags recovered from the tag releases during a specific time stratum (π) and the percentage of tagged fish in samples collected during tag recovery surveys (ρ). The recovery data from each major area were tested to determine if there were significant temporal differences in both of these percentages. The results of these tests determined which data were pooled and which model was used to estimate the abundance of coho salmon using the recovery data for a specific area or group of areas pooled.

Tag Releases

Tagging began on 7 September and continued through 7 November. A total of 670 coho salmon were tagged during 24 days of tagging (Table 1). About 23% of the tagged fish were eventually recovered during surveys conducted to estimate the percentage of tagged fish in the escapement.

The percentage of each day's release of tags that were recovered ranged from 0% to 33% (Figure 5). Generally, coho salmon tagged and released during September were recovered at a higher rate than those tagged and released in October and November. Four temporal release strata were defined to determine if there were significant differences in π among the release strata using the recoveries at each major area. The four release strata were:

1. 7 September to 21 September;
2. 26 September to 3 October;
3. 8 October to 25 October; and
4. 29 October to 7 November.

Significant differences in π among the release strata were found for the recoveries at Marblemount Hatchery, the combined upriver spawning grounds, and the commercial fishery (Table 2). There were no significant temporal differences in π among release strata at the only other major recovery areas (Baker River trap and for all recovery areas combined). These tests were conducted only for recovery areas with seven or more legible tag recoveries.

Table 1. Number of coho salmon tagged each day and number of in-sample tag recoveries from each day's release for the Skagit River, 1990.

Date	Number Tagged	Tag Recoveries by Area[a]											Recoveries	
		MMH	BAK	MSK	USK	LSA	MSA	USA	SUI	OTH	CFS	TFS	Total	(%) π
07-Sep	13	4	0	0	0	0	0	0	0	0	0	0	4	30.8%
10-Sep	15	1	0	0	0	0	0	0	0	0	1	0	2	13.3%
11-Sep	10	2	0	0	0	0	0	0	0	0	0	0	2	20.0%
14-Sep	41	2	2	0	0	0	0	0	0	0	3	1	8	19.5%
19-Sep	40	5	4	0	0	0	0	0	0	0	0	0	9	22.5%
20-Sep	14	2	0	0	0	0	0	0	0	0	0	0	2	14.3%
21-Sep	28	1	0	0	0	0	0	0	0	0	0	0	1	3.6%
26-Sep	23	4	1	0	0	0	0	0	0	0	1	0	6	26.1%
27-Sep	31	7	1	0	0	0	0	0	0	0	1	0	9	29.0%
28-Sep	32	7	0	0	0	0	0	0	0	0	1	0	8	25.0%
03-Oct	73	8	3	0	0	0	0	0	0	1	0	0	12	16.4%
08-Oct	57	6	3	1	0	1	0	0	0	0	0	0	11	19.3%
09-Oct	78	11	1	0	2	0	0	0	0	0	1	0	15	19.2%
12-Oct	13	3	0	0	0	0	0	0	0	0	0	0	3	23.1%
15-Oct	21	2	0	0	0	0	0	0	0	0	0	0	2	9.5%
19-Oct	41	7	0	0	0	0	0	0	0	0	0	0	7	17.1%
24-Oct	27	3	0	0	0	0	0	0	0	0	0	0	3	11.1%
25-Oct	38	3	0	0	1	2	0	0	0	0	0	0	6	15.8%
29-Oct	10	0	0	0	0	0	1	0	0	0	0	0	1	10.0%
30-Oct	3	1	0	0	0	0	0	0	0	0	0	0	1	33.3%
31-Oct	8	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
05-Nov	20	0	0	0	1	1	1	0	0	0	0	0	3	15.0%
06-Nov	17	0	0	1	0	0	0	0	0	0	2	0	3	17.6%
07-Nov	17	2	0	0	0	0	0	0	0	0	2	0	4	23.5%
UNKNOWN[b]		26	1	1	2	0	2	0	0	0	0	0	32	
TOTALS	670	107	16	3	6	4	4	0	0	1	12	1	154	
% Recovered		16.0%	2.4%	0.4%	0.9%	0.6%	0.6%	0.0%	0.0%	0.1%	1.8%	0.1%	23.0%	

[a] Locations are: MMH - Marblemount Hatchery; BAK - Baker River trap; MSK - Middle Skagit sub-basin; USK - Upper Skagit sub-basin; LSA - Lower Sauk sub-basin; MSA - Middle Sauk sub-basin; USA - Upper Sauk sub-basin; SUI - Suiattle sub-basin; OTH - Cascade, Nookachamps, and Carpenter sub-basins; CFS - Commercial fishery; and TFS - Test fishery.

[b] Fish recovered with no tag but having the secondary mark (an operculum punch) or an illegible tag.

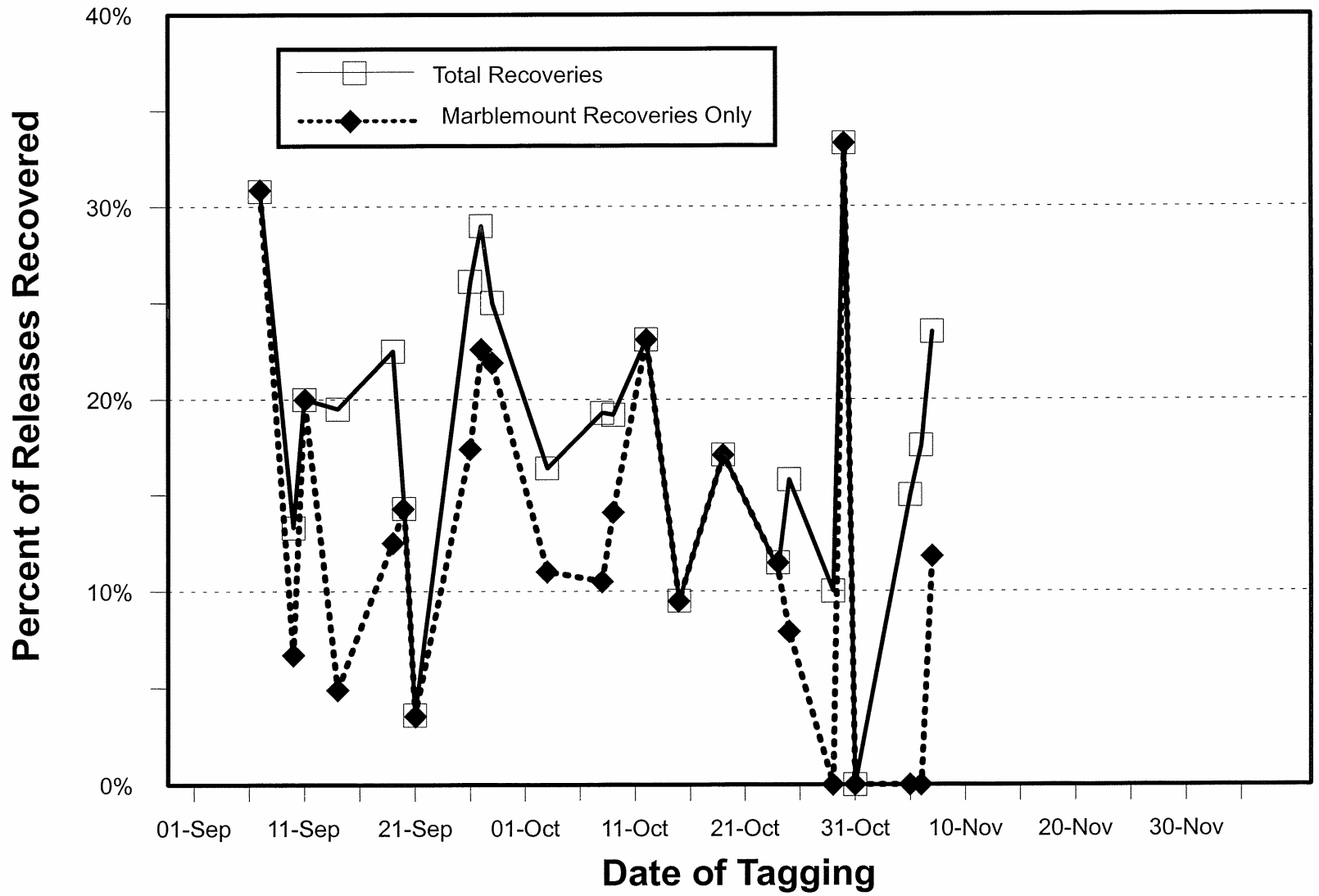

Figure 5. Percent of tags recovered during in-sample surveys from each day of release for coho salmon tagged in the Skagit River, 1990.

Table 2. Summary of the number of tag recoveries (#) from each release stratum in each major recovery area and the results of testing recovery percentages (π) for equality among release strata, 1990.

		RECOVERY AREA									
	Number	Marblemount		Baker		Spawn Gr.[a]		Comm. Fishery		Total	
Release Strata	Tagged	#	π	#	π	#	π	#	π	#	π
7-Sep thru 21-Sep	161	17	10.6%	6	3.7%	0	0.0%	3	1.9%	28	17.4%
26-Sep thru 3-Oct	159	26	16.4%	5	3.1%	1	0.6%	3	1.9%	35	22.0%
8-Oct thru 25-Oct	275	35	12.7%	4	1.5%	7	2.5%	0	0.0%	47	17.1%
29-Oct thru 7-Nov	75	3	4.0%	0	0.0%	5	6.7%	4	5.3%	12	16.0%
TOTALS	670	81	12.1%	15	2.2%	13	1.9%	10	1.5%	122	18.2%
TEST RESULTS[b]											
Test Used:			χ^2		ART		ART		ART		χ^2
Significance (P):			0.05		0.11		< 0.01		0.01		0.55
			*		NS		***		**		NS

[a] Total for all spawning ground samples from the Middle Skagit sub-basin and above. The total does not include recoveries from Marblemount Hatchery, Baker River trap, or the Nookachamps and Carpenter sub-basins.

[b] Results of the tests to determine if the recovery percentages (π) were different among release strata. Test used: χ^2 = chi-square test, ART = approximate randomization test. NS = Not Significant, * = Significant, $0.05 < P \leq 0.10$, ** = Significant, $0.01 < P \leq 0.05$, *** = Significant, $P \leq 0.01$.

Tag Recoveries

Samples to estimate ρ were collected at 13 areas in the Skagit River drainage. A total of 15,478 coho salmon were examined of which 15,303 fish were considered in-sample and 175 were not considered part of the population subject to tagging. Sample surveys were conducted at: Marblemount Hatchery; Baker River trap; spawning grounds in the Middle Skagit, Upper Skagit, Lower Sauk, Middle Sauk, Upper Sauk, Suiattle, Cascade, Nookachamps, and Carpenter sub-basins; and in commercial and test fisheries. Of the 154 in-sample recoveries, 32 fish (21%) had a tag with an illegible number or had a missing tag and were identified as tagged by the opercula punches. Most of the in-sample recoveries were at Marblemount Hatchery (107 recoveries or 69% of all in-sample recoveries). The areas with the next largest number of tag recoveries were Baker River (16 or 10%) and the upstream commercial fishery (10 or 6%). Combined, these three areas accounted for 86% of all in-sample recoveries.

The percentage of tagged fish in the escapement samples (ρ) from the three upstream recovery areas having seven or more tag recoveries ranged from 1.2% for the samples collected at the Baker River trap to 1.5% for Marblemount Hatchery and the commercial fishery samples (Table 3). There was not a significant difference in ρ (χ^2, $P = 0.68$) among these three areas.

The average number of days between release and recovery for in-sample tag recoveries was about 50 days. Tagged coho salmon recovered in the commercial fishery had the shortest average time between release and recovery, 10 days, and tag recoveries from the Middle Sauk sub-basin had the longest average time between release and recovery, 85 days (Table 4). For the upstream recovery areas, tag recoveries at Baker River trap had the earliest average day of release (27 September) and recoveries from the Middle Sauk sub-basin had the latest average day of release (1 November).

Marblemount Hatchery:

Escapement samples were collected at Marblemount Hatchery from 22 September through 30 January. A total of 7,329 coho salmon were examined and 107 tagged fish (1.5%) were found (Appendix Table A-1). The Marblemount Hatchery sample is considered a census because all returning fish are sampled so the data were not examined for temporal differences in ρ.

Baker River Trap:

Escapement samples were collected at Baker River trap from 7 September through 21 December. A total of 1,382 coho salmon were examined for tags. Based upon a four-day minimum travel time from the tagging area to Baker River dam determined from all five years of tagging data (Conrad et al. 1997), samples collected prior to 11 September were not considered in-sample since tagging did not begin until 7 September. No fish were counted during the sampling on 7 and 10 September. A total of 1,382 coho salmon were examined for tags from 14 September through 21 December and 16 tagged fish (1.2%) were found (Appendix Table A-2). The Baker River trap sample is considered a census because all returning fish are sampled so the data were not examined for temporal differences in ρ.

Table 3. Summary of the percentage of tagged or marked coho salmon found in each recovery area during in-sample surveys of the Skagit River, 1990.

Recovery Area	Time Period	Fish Examined	Tags Found[a]	% Tagged (ρ)
Marblemount Hatchery	1. 22-Sep - 30-Jan	7,329	107	1.5%
Baker River Trap	X.[b] 07-Sep - 10-Sep	0	0	0.0%
	1. 14-Sep - 21-Dec	1,382	16	1.2%
Commercial Fishery	1. 17-Sep - 18-Dec	687	10	1.5%
Upper Skagit Sub-basin	1. 01-Oct - 07-Mar	230	6	2.6%
Middle Sauk Sub-basin	1. 25-Oct - 05-Feb	283	4	1.4%
Lower Sauk Sub-basin	1. 31-Oct - 08-Feb	154	4	2.6%
Middle Skagit Sub-basin	1. 12-Oct - 15-Feb	349	3	0.9%
Cascade Sub-basin	1. 25-Sep - 14-Feb	117	1	0.9%
Suiattle Sub-basin	1. 19-Nov - 07-Feb	30	0	0.0%
Upper Sauk Sub-basin	1. 20-Nov - 22-Jan	9	0	0.0%
IN-SAMPLE TOTAL FOR UPSTREAM AREAS		10,570	151	1.4%
Nookachamps Sub-basin	1. 23-Oct - 28-Jan	73	0	0.0%
Carpenter Sub-basin	1. 28-Oct - 29-Jan	33	0	0.0%
Commercial Fishery	1. 13-Sep - 17-Dec	3,181	2	0.1%
Test Fishery	X. 22-Aug - 06-Sep	175	0	0.0%
	1. 10-Sep - 09-Nov	1,446	1	0.1%
IN-SAMPLE TOTAL FOR DOWNSTREAM AREAS		4,733	3	0.1%
TOTAL CONSIDERED IN POPULATION BEFORE TAGGING		175	0	0.0%
IN-SAMPLE TOTAL FOR ALL AREAS		15,303	154	1.0%
GRAND TOTAL FOR ALL SAMPLES		15,478	154	1.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

[b] X indicates that these fish were considered to be in the population before tagging began and not subject to tagging (i.e., they were not considered in-sample fish for the abundance estimates).

Table 4. Average day of release (DOR) and average number of days between release and recovery (DBET) for coho salmon tagged and recovered in the Skagit River, 1990.

Recovery Area	Sample Size[a]	Average DOR	Stand. Error	Range	Average DBET	Stand. Error	Range
Marblemount Hatchery:							
Pond Mortalities	11	1-Oct	2.7	14-Sep - 12-Oct	49.0	2.2	35 - 61
Surplussed	3	7-Sep	0.0	7-Sep - 7-Sep	64.7	32.7	32 - 130
Spawned	51	3-Oct	2.1	7-Sep - 7-Nov	60.1	2.2	20 - 105
Above Rack	16	11-Oct	2.0	28-Sep - 25-Oct	61.3	3.0	41 - 86
Baker River Trap	15	27-Sep	2.4	14-Sep - 9-Oct	23.1	2.7	12 - 42
Commercial Fishery	12	6-Oct	6.9	10-Sep - 7-Nov	9.9	2.0	4 - 27
Upper Skagit Sub-basin	4	19-Oct	6.6	9-Oct - 5-Nov	71.5	10.1	56 - 101
Middle Sauk Sub-basin	2	1-Nov	3.5	29-Oct - 5-Nov	85.0	7.0	78 - 92
Lower Sauk Sub-basin	4	23-Oct	5.8	8-Oct - 5-Nov	49.5	7.3	32 - 63
Middle Skagit Sub-basin	2	22-Oct	14.5	8-Oct - 6-Nov	34.5	16.5	18 - 51
Cascade Sub-basin	1	3-Oct			48.0		
Test Fishery	1	14-Sep			22.0		
All Recoveries	122	5-Oct	1.4	7-Sep - 7-Nov	49.5	2.2	4 - 130

[a] Includes tag recoveries with legible numbers only.

Commercial and Test Fishery Samples:

A commercial fishery was conducted in the river and in Skagit Bay on 39 days between 13 September and 18 December. Catches from areas above and below the tagging site were sampled. A total of 687 coho salmon were examined for tags and 10 tagged fish (1.5%) were found in catches from areas above the tagging site (Appendix Table A-3). The hypothesis of constant ρ for temporal strata in the fishery samples from the upstream areas could not be rejected. Two tagged coho salmon were found in 3,181 fish examined from catches in downstream areas (including Skagit Bay). Recovery data collected from the downstream areas were considered out-of-population and not used for the abundance estimates.

Test fisheries were conducted on 20 days between 22 August and 9 November. Recovery data collected prior to 7 September were excluded from analysis since tagging did not commence until that date. A total of 1,621 coho salmon were examined for tags. Of this total, 1,446 fish were examined after 6 September and one tagged fish (0.1%) was found (Appendix Table A-4).

Middle Skagit Sub-basin:

Tag recovery samples were collected during surveys of Middle Skagit sub-basin spawning grounds conducted from 18 October through 15 February and at a trap on Etach Slough operated from 12 October through 26 January. Surveys were conducted by SSC crews. A total of 349 coho salmon were examined for tags and three tagged fish (0.9%) were found (Appendix Table A-5).

Upper Skagit Sub-basin:

Tag recovery samples were collected during surveys of Upper Skagit sub-basin spawning grounds conducted from 1 October through 7 March. Surveys were conducted by SSC crews. A total of 230 coho salmon were examined for tags and six tagged fish (2.6%) were found (Appendix Table A-6).

Lower Sauk Sub-basin:

Tag recovery samples were collected during surveys of Lower Sauk sub-basin spawning grounds conducted from 31 October through 8 February. Surveys were conducted by SSC crews. A total of 154 coho salmon were examined for tags and four tagged fish (2.6%) were found (Appendix Table A-7).

Middle Sauk Sub-basin:

Tag recovery samples were collected during surveys of Middle Sauk sub-basin spawning grounds conducted from 25 October through 5 February. Surveys were conducted by SSC crews. A total of 283 coho salmon were examined for tags and four tagged fish (1.4%) were found (Appendix Table A-8).

Upper Sauk Sub-basin:

Tag recovery samples were collected during surveys of Upper Sauk sub-basin spawning grounds conducted from 20 November through 22 January. Surveys were conducted by SSC crews. Access to the spawning areas was limited by high flows. Only nine coho salmon were examined for tags and no tagged fish (0.0%) were found (Appendix Table A-9).

Suiattle Sub-basin:

Tag recovery samples were collected during surveys of Suiattle sub-basin spawning grounds conducted from 19 November through 7 February. Surveys were conducted by SSC crews. Access to the spawning areas was limited by high flows. Only 30 coho salmon were examined for tags and no tagged fish (0.0%) were found (Appendix Table A-10).

Other Spawning Ground Surveys:

Spawning ground surveys were conducted in three other areas: Nookachamps sub-basin, Carpenter sub-basin, and Cascade sub-basin. Tag recovery samples were collected during surveys of Nookachamps sub-basin spawning grounds by SSC crews. A total of 73 coho salmon were examined for tags but no tagged fish (0.0%) were found (Appendix Table A-11). Spawning ground surveys of the Carpenter sub-basin were conducted by SSC crews and a trap was operated by SSC on Carpenter Creek Slough. A total of 33 coho salmon were examined for tags but no tagged fish (0.0%) were found in these samples (Appendix Table A-12). SSC crews surveyed Cascade sub-basin spawning grounds. A total of 117 coho salmon were examined for tags and one tagged fish (0.9%) was found (Appendix Table A-13).

Out-of-System Recoveries:

There was one recovery of a jaw tag outside of the Skagit River system from the tagging in the Skagit River during 1990. The tag was recovered during sampling at Grover's Creek Hatchery on the northeast side of the Kitsap Peninsula.

Abundance Estimates

Estimates of coho salmon abundance from the tag recovery data for each major recovery area having seven or more tag recoveries are summarized in Table 5. The details of the abundance estimate for each location are in Appendix B.

The samples from Marblemount Hatchery and Baker River trap were both censuses so they were compared to determine if it was appropriate to pool them. The percentages of tags in the two samples were not significantly different (χ^2, $P = 0.38$) so an estimate was generated with the pooled data.

The commercial fishery occurred during two discrete time periods with a 46-day interval between them. There was not a significant difference in the percentage of tags in the two samples (Fisher's exact test, $P = 0.46$) so the data from the two periods were pooled. An estimate was generated using the pooled data.

The pooled commercial fishery data were then compared to the sample data from Marblemount Hatchery and the Baker River trap. There was not a significant difference in the percentage of tags among the three samples (χ^2, $P = 0.68$) so the data from all three recovery areas were pooled to produce an estimate.

Estimates of the number of coho salmon migrating through the tagging area in the lower Skagit River ranged from 41,967 coho salmon using the commercial fishery recovery data to 54,587 coho salmon using Baker River trap recovery data (Table 5). Pooled Marblemount-Baker-commercial fishery data provided the most precise estimate (CV = 7.6%). The estimate with the largest CV was from the commercial fishery recovery data (CV = 28.4%). The 95% confidence intervals for the abundance estimates overlapped for each recovery area.

Additional Analyses

The release data were divided into ten, 10-day time periods for the migratory timing analysis and to describe temporal patterns in the length and sex composition of tagged coho salmon. Coho salmon were tagged and released during seven of these periods.

Timing of Migrations to Major Recovery Areas:

The CPUE of coho salmon by the beach seine in the lower river tagging area is shown by day and for each 10-day period in Figure 6. CPUE peaked during the 1 October through 10 October time period. Two areas had ten or more recoveries of legible tags which could be used for the migratory timing calculations (Appendix Table A-14). The trends in CPUE of Marblemount Hatchery fish and fish bound for Baker River were very similar to the trend for total CPUE by 10-day period (Figure 7). CPUE of both groups peaked during the 1 October to 10 October period. Coho salmon from every period with tag releases were recovered at Marblemount Hatchery: this was the only area in which this occurred.

Length and Sex Composition Analyses:

The sex and length data for the 670 coho salmon tagged and released in the lower Skagit River and the 122 in-sample recoveries with legible tags were analyzed. The K-S and M-W tests which compared the lengths of coho salmon tagged but not recovered to the lengths of those tagged and recovered were both significant ($P < 0.05$) indicating that the recovery samples were not random with respect to length of fish. There was also a significant difference between male and female length distributions (K-S test, $P < 0.01$), therefore, all subsequent analyses of length were conducted for each sex separately. It is evident from Figure 8 that male coho salmon had a higher proportion of smaller sizes (fish less than 50 cm) than female coho salmon. Coho salmon less than 50 cm in length composed about 35% of the males that were tagged but only 5% of the female coho salmon that were tagged.

Table 5. Summary of estimates of the number of coho salmon in the Skagit River escapement using data from each major recovery area, 1990.

Recovery Area	Estimation Method	Estimated Abundance	Stand. Error	CV[a]	95% Confidence Interval
Marblemount	Petersen	45,540	3,966	8.7%	38,626 - 56,524
Baker River	Petersen	54,587	12,624	23.1%	32,407 - 94,446
Marblemount - Baker pooled	Petersen	47,142	3,780	8.0%	40,366 - 57,549
Commercial Fishery	Petersen	41,967	11,919	28.4%	21,542 - 86,535
Marblemount -Baker Commercial Fishery pooled	Petersen	47,064	3,598	7.6%	40,507 - 56,955

[a] CV = coefficient of variation.

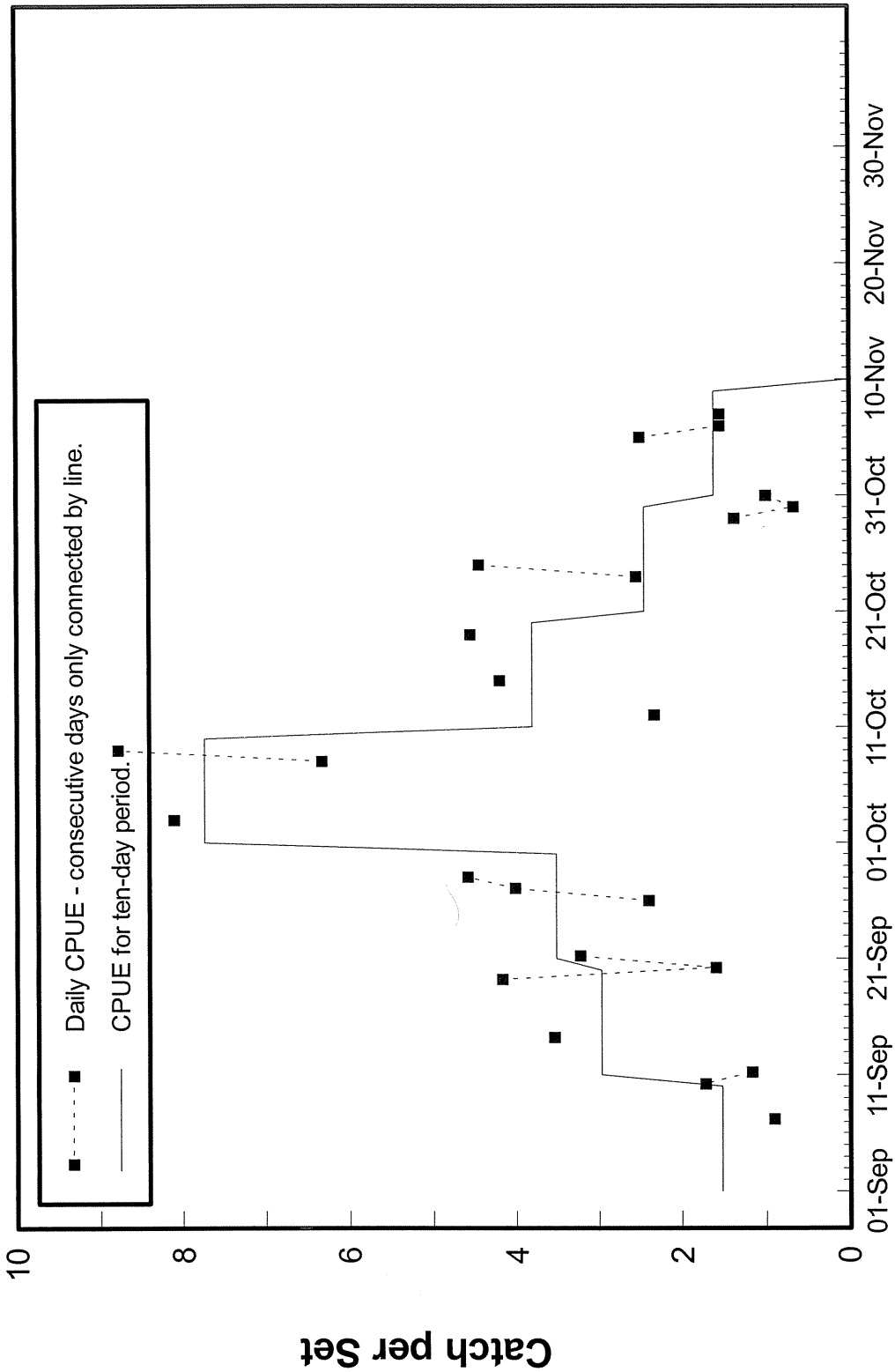

Figure 6. Catch-per-unit effort of coho salmon by the beach seine in the lower Skagit River tagging area by day and for each ten-day period, 1990.

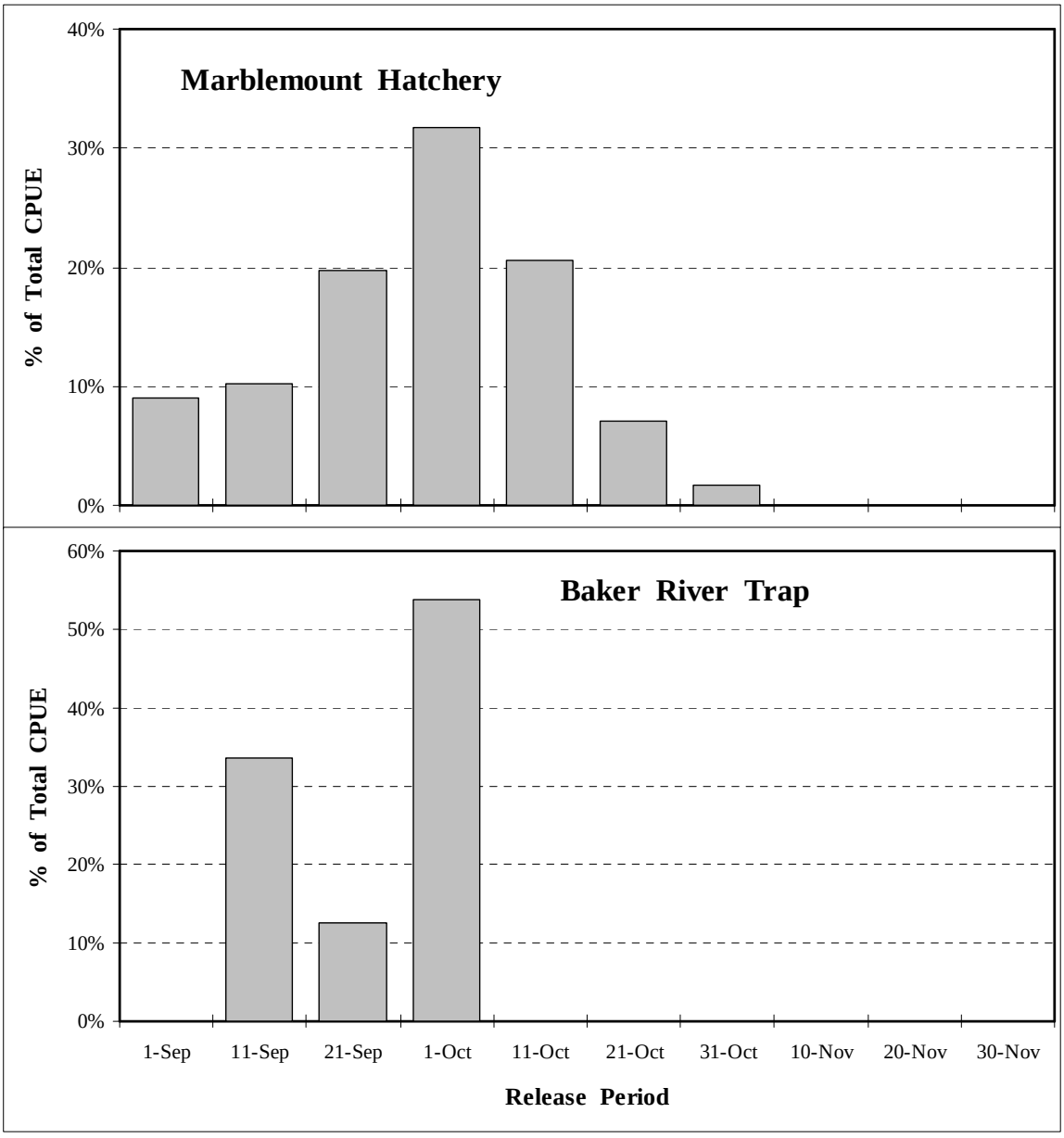

Figure 7. Beach seine catch-per-unit effort (CPUE) of coho salmon bound for major Skagit River tag recovery areas in 1990. CPUE is for ten-day periods (starting date of period shown) and is expressed as a percentage of the total CPUE for tagged fish recovered from the area.

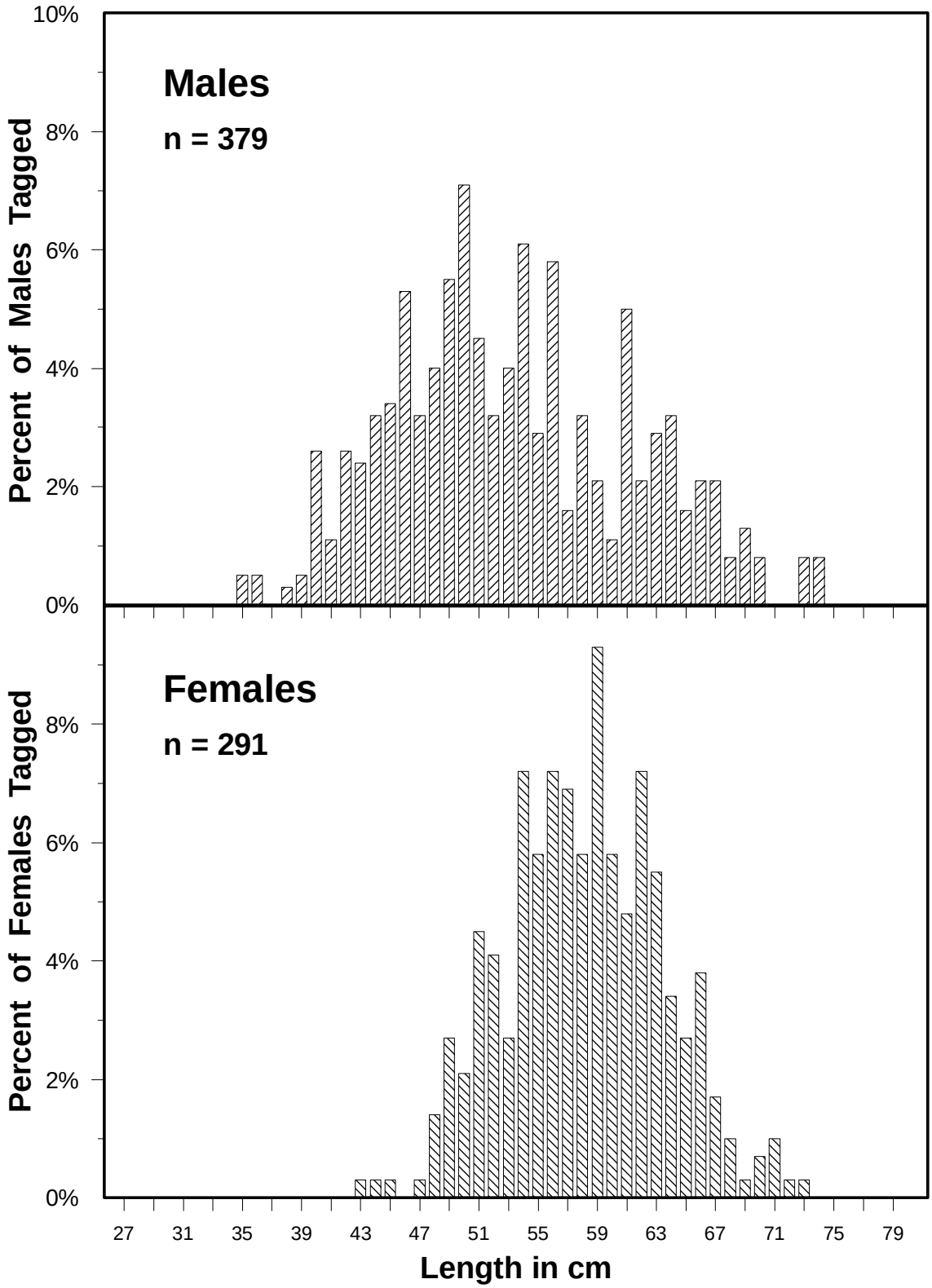

Figure 8. Comparison of length frequencies of male and female coho salmon tagged in the lower Skagit River, 1990.

Males Tagged male coho salmon averaged 53.3 cm in fork length (SE = 0.42). The mean length of male coho salmon that were tagged but not recovered was 53.5 cm (SE = 0.48) compared to a mean length of 52.5 cm (SE = 0.80) for male coho salmon that were tagged and recovered. The length distribution of male coho salmon that were tagged but not recovered was not significantly different (K-S test, $P = 0.36$) from the distribution of those that were tagged and recovered (Figure 9). Therefore, sequential K-S tests were not conducted (Appendix Table A-15).

Females Tagged female coho salmon averaged 58.1 cm in fork length (SE = 0.32). The mean length of female coho salmon that were tagged but not recovered was 58.3 cm (SE = 0.34) compared to a mean length of 56.9 cm (SE = 0.79) for female coho salmon that were tagged and recovered. The length distribution of female coho salmon that were tagged but not recovered was not significantly different (K-S test, $P = 0.28$) from the distribution of those that were tagged and recovered (Figure 9). Therefore, sequential K-S tests were not conducted (Appendix Table A-15).

Tag Recovery Rates There was not a significant difference (χ^2, $P = 0.16$) in tag recovery rates between male and female coho salmon. Tag recovery rates were 20.1% and 15.8% for male and female coho salmon, respectively (Appendix Table A-16). There was not a significant difference in tag recovery rates among the release condition categories (only one fish was released with a condition of x-) or the maturity categories (χ^2, $P = 0.22$) either (Appendix Table A-16).

Sex-Length Composition There were temporal changes in both the sex composition and length composition for each sex during the tagging period (Figure 10). The majority of the coho salmon tagged were males during the first five time periods (7 September to 20 October) and females during the last two time periods (21 October to 9 November). Both male and female coho salmon were classified into two length groups, small (≤ 49 cm) and large (≥ 50 cm). The percentage of small males decreased throughout the release period as the percentage of large males increased. The large length group composed 89% or more of the female coho salmon tagged throughout the period of tagging.

Conclusions

In 1990, there were only three recovery areas with seven or more tag recoveries. The percentage of tagged or marked coho salmon (ρ) in these samples was very consistent: 1.5% for the samples collected at Marblemount Hatchery and in the commercial fishery and 1.2% for the samples collected at Baker River trap. There were no tags recovered from spawning areas below the tagging site. There were, however, three tags recovered in 4,627 coho salmon examined (0.1%) from in-population test fishery and commercial catch samples from areas downstream of the tagging site.

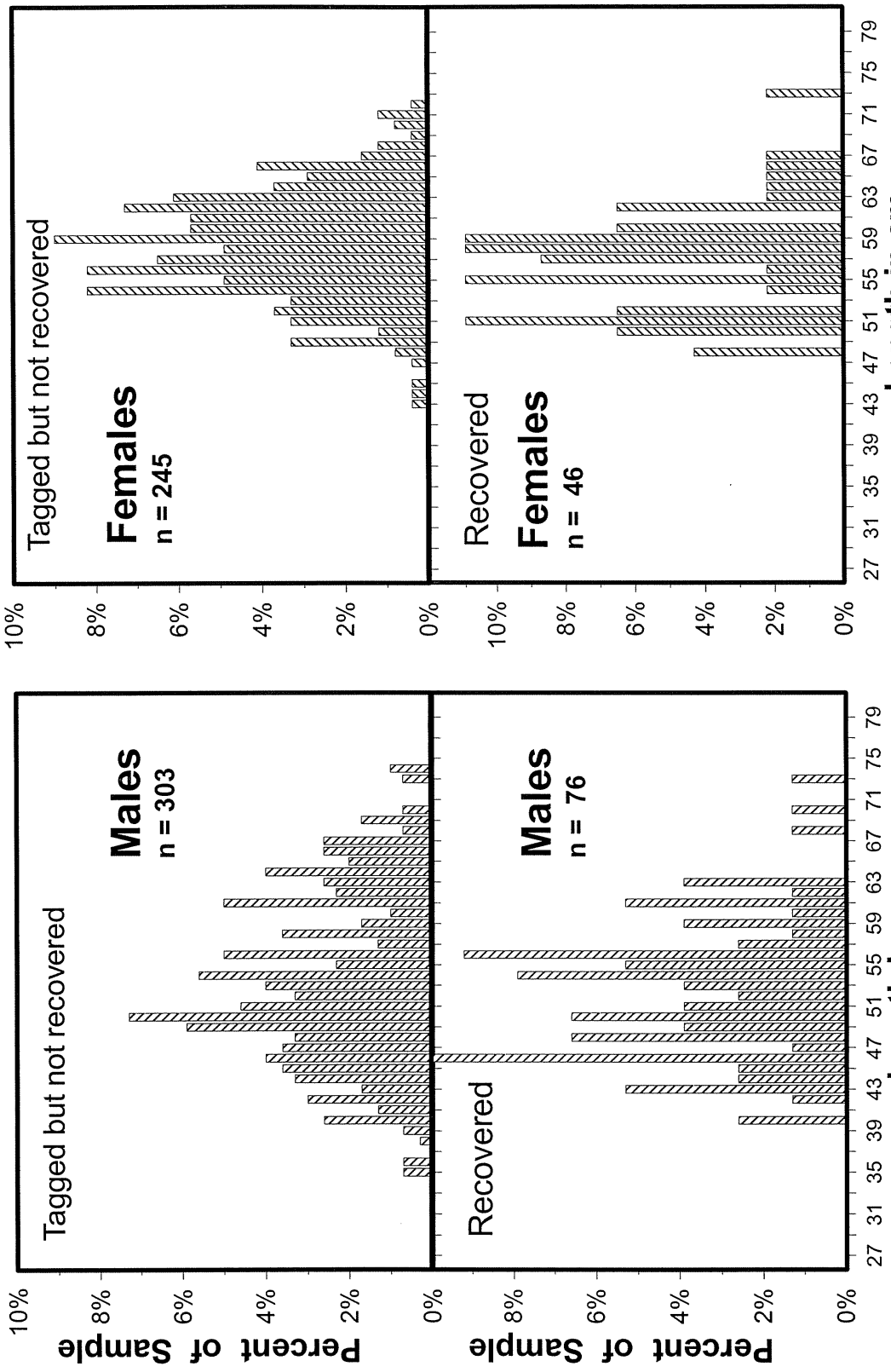

Figure 9. Comparison of length frequencies of coho salmon that were tagged but not recovered to those that were tagged and recovered, for males and females, 1990.

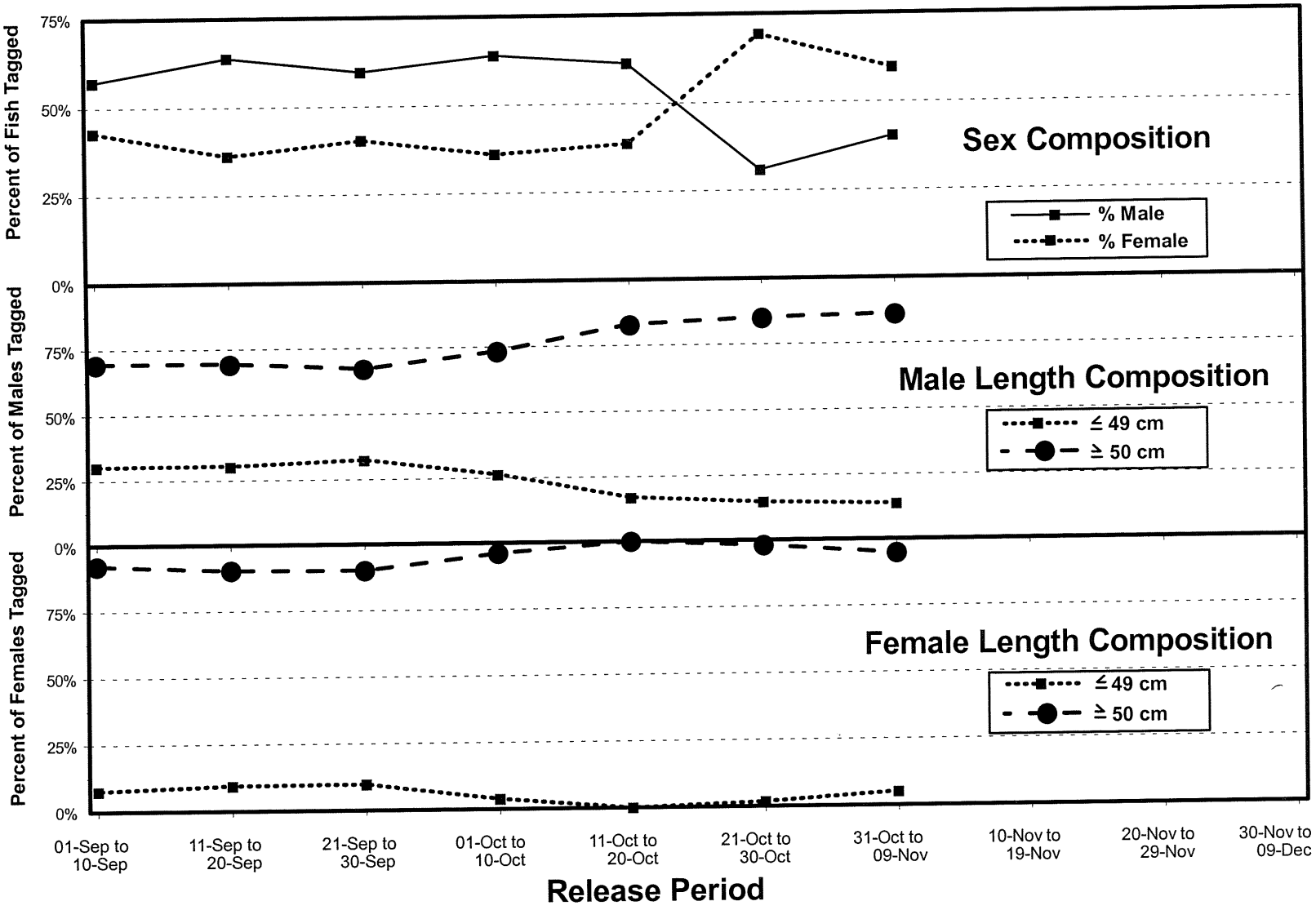

Figure 10. Sex and length composition, by release period, of coho salmon tagged in the lower Skagit River, 1990.

We recommend that the estimate using the pooled Marblemount-Baker-commercial fishery data be considered the "best" estimate of coho salmon abundance for 1990. There was not a significant difference in ρ between these areas, fish from these areas were well distributed throughout the release period, and two of the samples were censuses. This estimate uses the largest number of tag recoveries (133) and therefore has the smallest CV.

The estimate, 47,064 coho salmon (95% confidence interval: 40,507 to 56,955), is for the number of fish present in the lower Skagit River tagging area during the period 7 September to 7 November. Similarly to 1989, there is no evidence that coho salmon from spawning areas downstream of the tagging site were present in the tagging area. No tags (0) were recovered from 106 coho salmon examined in the escapement to the Nookachamps and Carpenter sub-basins. However, we feel that some coho salmon from these areas were present as in previous years but the level of sampling in 1990 was not sufficient to detect them. Also, the tagged fish recovered from the commercial and test fisheries in areas downstream of the tagging site provide additional evidence that coho salmon from downstream spawning areas might have been present at the tagging site. Therefore, the estimate includes coho salmon bound for all spawning grounds above the tagging area and some portion of the escapement to areas downstream of the tagging site.

DISCUSSION

The number of coho salmon in the escapement to the Skagit River was estimated using the tag release-and-recovery data and the Petersen model. A discussion of how well the data meet the major assumptions of the Petersen model and a definition of the "population" which is being estimated follows.

Population was Closed

We assume that some coho salmon migrated through the tagging area before and after the period of tagging (7 September through 7 November). Although the Petersen model generally assumes a closed population, the population can be open but the exact point in time to which the estimate applies must be specified (Seber 1982). We feel the trend in CPUE for the beach seine used to capture coho salmon for tagging provides strong evidence that the tagging period encompassed the major portion of the coho salmon migration. The CPUE was low when tagging began and was followed by an increase in CPUE to a peak during the period 1 October through 10 October. This was followed by a decline in CPUE during mid and late October and early November (Figure 6).

Unlike in 1986, 1987, 1988, and 1989, no adjustments to the total number of fish examined at either Baker River trap or Marblemount Hatchery were required to account for early-arriving fish that were not subject to tagging. Only 12 coho salmon arrived at the Baker River trap prior to the onset of tagging. These fish were not sampled. Therefore, there is no evidence that there were large numbers of fish in the population prior to the start of tagging.

If we assume there is recruitment to the population (coho salmon migrating through the tagging area after tagging ends) but no mortality before the fish reach their spawning areas, and there is complete mixing of the fish on the spawning grounds, then the abundance estimate includes coho salmon migrating through the tagging area after the last day of tagging. Sampling at Marblemount Hatchery and at Baker River trap was conducted through 30 January and 21 December, respectively. Tag recovery surveys were conducted in most sub-basin spawning grounds until late January or early February. We feel there was sufficient time for coho salmon migrating through the tagging area in the lower river after tagging had ended to mix with the fish already present on the spawning grounds and at Marblemount Hatchery.

Area Encompassed by the Estimates:

The Petersen model estimates the number of coho salmon migrating though the tagging area in the lower river during the time period defined above. The estimate includes all coho salmon bound for spawning areas above the tagging area (including Marblemount Hatchery and Baker River) and all spawning areas in the Middle Skagit sub-basin above and including Hansen Creek (Figure 1). However, the percentage of tags in the combined samples from areas downstream of the tagging site, 0.10% (including downstream commercial and test fishery samples), was much smaller than in the upstream recovery areas (1.4%). Although no tags

were recovered from 106 coho salmon examined in the spawning areas of the Nookachamps and Carpenter sub-basins, we feel that some coho salmon from these areas were present in the tagging area, as in previous years, but the levels of tagging and spawning ground sampling in 1990 were not sufficient to detect them. Therefore, we conclude that the abundance estimate includes a portion of the coho salmon which spawned in the Carpenter and Nookachamps sub-basins. If the total number of tagged fish that migrated to these downstream areas could be estimated, this number could be removed from the total number of tags released and the abundance estimate would include only coho salmon bound for areas **upstream** of the tagging site and the Middle Skagit sub-basin. We estimated the number of tags "lost" to the downstream areas so that we could examine the effect of these tags on the abundance estimate for the upstream areas.

Estimate of the Number of Tagged Fish "Lost" to Areas Downstream of the Tagging Area:

Three groups of fish from areas downstream of the tagging area were examined for tags: (1) commercial fishery catches; (2) test fishery catches, and (3) fish spawning in the Carpenter and Nookachamps sub-basins. The commercial catch in area 78D was sampled by subareas (78D-2, 78D-3, and 78D-4; see Figure 4) in 1990 so we could estimate the percentage of tags in samples above and below the tagging area. The total commercial catch from area 78D is not recorded by these sub-areas, however. Therefore, we assumed that the proportional catch by sub-area for the commercial catch samples was the same as the entire commercial catch for area 78D. We pooled all downstream catches and applied the percentage of tags found in downstream commercial and test fishery samples (Area 2, Spudhouse, Blakes, and Jetty; see Figure 4) to the pooled total. The number of tagged fish present on spawning grounds in the Carpenter and Nookachamps sub-basins was estimated by applying the percentage of tags found during in-sample surveys of these sub-basins combined (no tagged fish found in 311 fish examined for $\rho = 0.0\%$) to an independent estimate of the number of coho salmon spawning in these sub-basins. The spawning ground escapement to these sub-basins was estimated using a redd-count method (Conrad et al. 1993). Plus there was the single out-of-system tag recovery at Grover's Creek Hatchery. The numbers used for these calculations are summarized in Appendix Table A-17. We estimated that a total of nine tags could have been "lost" to these downstream areas. If the number of tags released is adjusted to 661 (670 - 9), then (using the pooled Marblemount-Baker River-commercial fishery recovery data) the estimated abundance for areas upstream of the tagging area becomes 46,433 coho salmon. This is only 631 fish less than the "unadjusted" estimate and is about a one percent difference from that estimate.

The presence in the tagging area of coho salmon bound for systems outside the Skagit River would also affect the abundance estimate. In 1990, there was only one out-of-system recovery from 670 coho salmon tagged (0.15%) in the lower Skagit River. Therefore, we do not feel that the loss of tagged coho salmon to systems outside the Skagit River was a major source of error.

All Coho Salmon Have an Equal Probability of Capture During Tagging or the Recovery Sample is a Simple Random Sample of the Population

These assumptions are often hard to satisfy as it is difficult or impossible to obtain simple random samples from highly dispersed and mobile populations. Fortunately, the estimates are still valid under certain alternative assumptions. Junge (1963) demonstrated that selectivity (non-randomness) may exist in both the tagging and recovery samples without introducing bias in the estimate if the sources of selectivity in the two samples are independent.

There was evidence that the recovery samples on the spawning grounds were selective with respect to the length of the fish, but when the sexes were analyzed separately there was no evidence of selection for length. There was evidence that length selectivity occurred in previous years (Conrad et al. 1997, 1998a, 1998b). Eames et al. (1981, 1983) found that there was a correlation between time of entry and size of coho salmon for the returns to the Skagit River in 1976 and 1977. Smaller fish generally arrived earlier in the run than larger fish. This presents a problem if timing of passage through the tagging area is correlated with the size of fish and area of spawning (Junge 1963). If such selectivity existed the population estimates would contain a negative bias. However, we believe if such a bias exists it is small because the majority of the tag recovery data used for the abundance estimate was collected from areas where there was no size selectivity (Marblemount Hatchery and Baker River trap).

The use of different gears for the tagging and recovery samples is a common technique for minimizing the bias due to selectivity (Ricker 1975; Seber 1982). In this study, coho salmon were captured for tagging using a beach seine. Recovery samples were either a census of all adults returning to an area (Marblemount Hatchery and Baker River trap) and thus non-selective, or were samples collected on the spawning grounds during foot surveys (and to a lesser extent by traps in some areas). We do not feel that selectivity (non-random sampling) was a significant source of bias for the estimates because: (1) the methods used to capture coho salmon for tagging were different from those used to recover them; and (2) the majority of the tag recoveries used to estimate abundance were collected by a census.

Tagging Does Not Affect the Catchability of an Animal

This assumption is necessary because some of the coho salmon passing through the tagging area were subject to an in-river commercial fishery above the tagging area. If jaw-tagged coho salmon were removed at a different rate than untagged fish, the percentage of tags in any recovery samples collected after this removal would be different from the percentage of tags in the population immediately after tagging. There is no evidence of selective removal of tagged fish in the data. In 1990, the percentage of tagged fish in the commercial fishery samples from the sub-areas of 78D upstream of the tagging area was the same as that observed at Marblemount Hatchery.

Animals Do Not Lose Their Tags Between the First and Second Samples

In 1990, 21% of the tagged coho salmon recovered had missing or illegible tags. However, the use of opercula punches on all tagged fish allowed coho salmon with missing tags to be identified as previously tagged. Identified tag loss must be accounted for only in the Darroch estimate of abundance which requires that the release period of recovered individuals be known. When there was no tag but an operculum punch was present (or the tag was illegible), the release period was estimated as described in the Methods section. This was required only when the Darroch estimate was selected as the appropriate model. The Darroch estimate was not used for any of the abundance estimates produced in 1990. The Petersen estimate was selected as the appropriate model for all estimates. As long as all coho salmon with a missing tag are identified by an operculum punch, the Petersen estimate is not affected by the missing tags.

All Tagged Animals are Reported in the Second Sample

Because the majority of the tag recoveries used for the abundance estimates were from Marblemount Hatchery, and all coho salmon at Marblemount Hatchery were inspected twice for tags, we expect very few jaw-tagged (or marked) fish were missed. Live fish were individually inspected for tags and marks at Baker River dam. During surveys of spawning grounds, surveyors carefully inspected each carcass for an operculum punch if no tag was visible. Considering that some carcasses were in an advanced state of decay it is possible that some fish with a missing tag were not identified. However, no spawning ground data were used in the abundance estimate for 1990.

There are No Mortalities Due to Tagging

Tests to determine the extent of tagging mortality were conducted during four of the five study years. These tests and their results are documented in Conrad et al. (1997). Based on these tests we concluded that there was no evidence of tagging mortality. The tests provided strong evidence that there was no short-term (within 48 hours) tagging mortality. The tag recovery data from the commercial fishery samples provide additional evidence that there was no delayed tagging-induced mortality occurring from two weeks up to three months after tagging. The average time between tag release and recovery for the commercial fishery recoveries, about 10 days (Table 4), was the shortest of any of the upstream recovery areas. Since the coho salmon caught in the commercial fishery are caught relatively soon after tagging, we would expect that if there is any delayed mortality caused by tagging it would cause the commercial fishery samples to have a higher percentage of tags than the samples that are taken much later, further upstream. In 1990, ρ for the commercial fishery samples from upstream areas (1.5%) was identical to that for Marblemount Hatchery. Unfortunately, there were insufficient recoveries from the spawning grounds above the tagging site for a valid comparison of recovery percentages.

CONCLUSIONS

The estimated abundance of coho salmon in 1990 was 47,064 fish with a 95% confidence interval of 40,507 to 56,955 fish. The mark-recapture estimate is for the number of coho salmon migrating through the tagging area after tagging began on 7 September. It includes all coho salmon bound for spawning areas above the tagging area and an unknown fraction of the salmon from spawning areas in the Nookachamps and Carpenter sub-basins. This abundance estimate was relatively precise (CV = 7.6%) because of the large number of fish examined for tags during the in-sample surveys used for the estimate and the relatively high percentage (for mark-recapture estimates) of the total number of fish tagged that were eventually recovered and used for the estimate (20%). To restrict the estimate to spawning areas in the Middle Skagit sub-basin and spawning areas above it, adjustments were made to the number of tags released. Using the adjusted number of tags released, the estimated abundance for this more restricted area was 46,433 coho salmon. The variance of this estimate was not calculated because of the unknown precision for the estimated number of tags "lost" to downstream areas. The adjusted estimate falls within the 95% confidence interval of the original estimate.

To estimate the number of "wild" coho salmon which reached upstream spawning areas in the Skagit River in 1990, the number of hatchery fish plus any catches by the commercial and test fisheries above the tagging area need to be removed from the adjusted estimate and the number of fish which migrated through the tagging area prior to tagging needs to be added. Since fish which migrated through the tagging area before tagging began are included in the spawning ground samples, only prior-migrating fish returning to Baker River and Marblemount Hatchery need to be included. Since both these returns were censused we have a total count of the prior-migrating fish to these areas. In 1990, there were only the 12 fish counted at the Baker River trap. Although all in-river catches were recorded on fish tickets, the sub-area of harvest within area 78D was not indicated on the ticket. Therefore, it was necessary to estimate the distribution of the commercial catch in area 78D to areas above and below the tagging site using the distribution of the commercial catch samples among areas 78D-1, 78D-2, 78D-3, and 78D-4. While there was uncertainty about this distribution, the total Area 78D catch was only 3,560 coho salmon of which 207 were known to have been caught in upstream areas and 326 were known to have been caught in downstream areas. Therefore, the maximum error possible from this allocation of catch to the sub-areas was 3,027 fish.

In-population sport catches should also be subtracted from the adjusted estimate. In-river catches of coho salmon by the sport fishery in the Skagit River were estimated to be only 497 fish in 1990 (WDF 1993) and were not included in the summary total as the specific dates and areas of harvest of these fish are unknown. A summary of the total terminal area run of coho salmon to the Skagit River in 1990 is presented in Table 6**. The total terminal area run of coho salmon to the Skagit River in 1990 is estimated to be 60,444 fish. An estimated 38,914 coho salmon were in the "wild" escapement to Skagit River spawning grounds**: 37,574 fish were estimated to have reached upstream spawning grounds and 1,340 coho salmon were estimated for lower river (Nookachamps and Carpenter sub-basin) spawning grounds. For comparison, the escapement of "wild" coho salmon to Skagit River spawning grounds estimated using index area surveys was 15,000 fish (Tim Flint, WDFW, personal

communication). This estimate is only 39% of the tagging estimate of the spawning escapement. An alternative estimate, derived from CWT recoveries in the test fisheries and trap recoveries (Hayman 1996), was for a wild escapement of 35,000 to 40,000 fish (depending upon the hatchery stray rate assumed). Using a redd-count method, Conrad et al. (1993) estimated the wild escapement to be 27,300 to 40,900 fish (assuming two or three coho salmon per redd, respectively).

Table 6. Summary of the number of coho salmon returning to Skagit Bay in 1990.

Component	In-Population	Out of Population	Total
Upstream Estimated Total	46,433	0	46,433
Marblemount Hatchery	7,329	0	7,329
Baker River Trap (Hatchery Fish[a])	629	0	629
Area 78D-3, 78D-4 Commercial Catch	901	0	901
Upstream Test Fishery Catch	0	0	0
Upstream Removals and Hatchery Fish	8,859	0	8,859
Estimated "Wild" Escapement to Upstream Spawning Areas	37,574		37,574
Nookachamps Sub-basin Estimated Escapement		1,139	1,139
Carpenter Sub-basin Estimated Escapement		201	201
Areas 78D-1, 78D-2, 78C, 8E, 8 Commercial Catches		11,043	11,043
Downstream Test Fishery Catch		1,628	1,628
Downstream Total		14,011	14,011
"Wild" Escapement[b] to Spawning Grounds	37,574	1,340	38,914[c]
Total Terminal Run to Skagit Bay	46,433	14,011	60,444[c]

[a] A total of 1,394 coho salmon returned to the Baker River trap (including 12 fish that returned prior to sampling). Of these, 1,369 coho were sampled and 618 fish were found to have an adipose fin clip which indicated they were of hatchery origin. The 25 unsampled fish were allocated as hatchery-origin or wild based on the proportion of each group observed in the sampled fish. Therefore, 11 of the 25 unsampled fish (25 x 618/1,369) were allocated to the hatchery-origin group and the remaining 14 fish to the wild group.

[b] Includes estimated "wild" escapement to upstream spawning areas and estimated escapement to the Nookachamps and Carpenter sub-basins (from Conrad et al. 1993).

[c] The estimated catch by the in-river sport fishery was 497 coho salmon, but the specific dates and areas of harvest of these fish are unknown. The total wild escapement should be reduced by the number of coho salmon caught in the sport fishery in upstream areas after tagging began. The total terminal run should be increased by the number caught in downstream areas or before tagging started.

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APPENDIX A

Summary tables of sample data for 1990.

Appendix Table A-1. Summary of coho salmon escapement samples collected at Marblemount Hatchery in 1990.

Sample Date	Sample Method	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
22-Sep	Spawned	440	0	0.0%
9-Oct	Surplused	947	4	0.4%
30-Oct	Pond Mortality	8	1	12.5%
6-Nov	Pond Mortality	7	1	14.3%
13-Nov	Pond Mortality	8	1	12.5%
14-Nov	Pond Mortality	7	1	14.3%
19-Nov	Pond Mortality	24	0	0.0%
20-Nov	Pond Mortality	2	1	50.0%
21-Nov	Pond Mortality	7	1	14.3%
26-Nov	Pond Mortality	104	3	2.9%
27-Nov	Pond Mortality	26	0	0.0%
	Spawned	1,104	20	1.8%
	Total	1,130	20	1.8%
28-Nov	Pond Mortality	25	1	4.0%
	Spawned	508	5	1.0%
	Total	533	6	1.1%
29-Nov	Pond Mortality	29	0	0.0%
	Spawned	392	8	2.0%
	Total	421	8	1.9%
30-Nov	Above Rack	26	1	3.8%
	Pond Mortality	2	0	0.0%
	Total	28	1	3.6%
3-Dec	Above Rack	42	1	2.4%
	Pond Mortality	29	1	3.4%
	Total	71	2	2.8%
4-Dec	Pond Mortality	20	1	5.0%
	Spawned	673	16	2.4%
	Total	693	17	2.5%
5-Dec	Above Rack	44	1	2.3%
	Pond Mortality	52	0	0.0%
	Total	96	1	1.0%
6-Dec	Above Rack	123	2	1.6%
7-Dec	Above Rack	67	1	1.5%
	Pond Mortality	10	0	0.0%
	Total	77	1	1.3%

- continued -

Appendix Table A-1. Summary of coho salmon escapement samples collected at Marblemount Hatchery in 1990 (continued).

Sample Date	Sample Method	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
10-Dec	Above Rack	209	3	1.4%
11-Dec	Above Rack	38	2	5.3%
	Pond Mortality	36	0	0.0%
	Spawned	650	8	1.2%
	Total	724	10	1.4%
12-Dec	Above Rack	75	4	5.3%
13-Dec	Above Rack	111	5	4.5%
	Pond Mortality	12	0	0.0%
	Total	123	5	4.1%
14-Dec	Above Rack	29	0	0.0%
17-Dec	Above Rack	161	0	0.0%
18-Dec	Above Rack	54	1	1.9%
	Pond Mortality	26	0	0.0%
	Total	80	1	1.3%
20-Dec	Spawned	445	3	0.7%
21-Dec	Above Rack	20	0	0.0%
	Pond Mortality	9	0	0.0%
	Total	29	0	0.0%
24-Dec	Above Rack	43	0	0.0%
26-Dec	Above Rack	30	1	3.3%
	Pond Mortality	19	0	0.0%
	Spawned	86	0	0.0%
	Total	135	1	0.7%
27-Dec	Above Rack	79	1	1.3%
28-Dec	Above Rack	28	0	0.0%
2-Jan	Above Rack	39	2	5.1%
	Pond Mortality	32	0	0.0%
	Spawned	68	2	2.9%
	Total	139	4	2.9%
3-Jan	Above Rack	38	0	0.0%
4-Jan	Above Rack	47	0	0.0%
9-Jan	Above Rack	13	0	0.0%
11-Jan	Pond Mortality	28	1	3.6%

- continued -

Appendix Table A-1. Summary of coho salmon escapement samples collected at Marblemount Hatchery in 1990 (continued).

Sample Date	Sample Method	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
15-Jan	Pond Mortality	23	0	0.0%
	Surplused	69	1	1.4%
	Total	92	1	1.1%
18-Jan	Above Rack	29	2	6.9%
	Pond Mortality	3	0	0.0%
	Total	32	2	6.3%
24-Jan	Above Rack	18	0	0.0%
25-Jan	Above Rack	7	0	0.0%
28-Jan	Above Rack	21	0	0.0%
29-Jan	Above Rack	3	0	0.0%
	Pond Mortality	2	0	0.0%
	Total	5	0	0.0%
30-Jan	Above Rack	3	0	0.0%
	Pond Mortality	550	13	2.4%
	Surplused	1,016	5	0.5%
	Spawned	4,366	62	1.4%
	Above Rack	1,397	27	1.9%
	IN-SAMPLE TOTAL	7,329	107	1.5%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-2. Summary of coho salmon escapement samples collected at Baker River trap in 1990.

Sample Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
7-Sep	0	0	0.0%
10-Sep	0	0	0.0%
Subtotal	0	0	0.0%
14-Sep	13	0	0.0%
17-Sep	5	0	0.0%
19-Sep	14	0	0.0%
21-Sep	12	0	0.0%
24-Sep	23	0	0.0%
26-Sep	34	0	0.0%
28-Sep	32	1	3.1%
1-Oct	26	0	0.0%
2-Oct	12	0	0.0%
3-Oct	20	0	0.0%
5-Oct	46	0	0.0%
8-Oct	68	1	1.5%
10-Oct	70	1	1.4%
12-Oct	139	2	1.4%
15-Oct	59	2	3.4%
17-Oct	64	0	0.0%
19-Oct	75	0	0.0%
22-Oct	101	0	0.0%
24-Oct	86	2	2.3%
26-Oct	102	3	2.9%
29-Oct	91	2	2.2%
31-Oct	11	1	9.1%
2-Nov	82	0	0.0%
5-Nov	40	1	2.5%
7-Nov	53	0	0.0%
9-Nov	41	0	0.0%
21-Nov	14	0	0.0%
5-Dec	49	0	0.0%
10-Dec	0	0	0.0%
12-Dec	0	0	0.0%
17-Dec	0	0	0.0%
19-Dec	0	0	0.0%
21-Dec	0	0	0.0%
IN-SAMPLE TOTAL	1,382	16	1.2%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-3. Summary of coho salmon catch samples collected from the commercial fishery in the Skagit River, 1990.

	UPSTREAM AREAS			DOWNSTREAM AREAS								
	Areas 78D, 78D-3, 78D-4			Areas 78D-1, 78C			Area 78D-2			Areas 8, 8E		
Sample Date	Number Exam.	Tags Found[a]	% w/Tags (ρ)	Fish Exam.	Tags Found[a]	% w/Tags (ρ)	Fish Exam.	Tags Found[a]	% w/Tags (ρ)	Fish Exam.	Tags Found[a]	% w/Tags (ρ)
13-Sep				148	0	0.0%						
14-Sep				96	0	0.0%						
17-Sep	18	0	0.0%				27	0	0.0%			
18-Sep				203	0	0.0%	293	1	0.3%			
19-Sep	141	3	2.1%	19	0	0.0%						
21-Sep										2	0	0.0%
24-Sep	10	0	0.0%				40	0	0.0%			
25-Sep	49	0	0.0%	135	0	0.0%				67	0	0.0%
26-Sep										1	0	0.0%
27-Sep										14	0	0.0%
28-Sep										89	0	0.0%
1-Oct										8	0	0.0%
2-Oct	276	3	1.1%				172	0	0.0%			
3-Oct				808	0	0.0%						
4-Oct										13	0	0.0%
5-Oct										146	0	0.0%
7-Oct										9	0	0.0%
9-Oct										217	0	0.0%
10-Oct										117	0	0.0%
12-Oct										4	0	0.0%
16-Oct										135	0	0.0%
18-Oct										11	0	0.0%
23-Oct										155	0	0.0%
26-Oct										7	0	0.0%
29-Oct				16	0	0.0%				58	0	0.0%
30-Oct				12	0	0.0%				62	0	0.0%
3-Nov										3	0	0.0%
5-Nov				10	0	0.0%				11	1	9.1%
6-Nov										6	0	0.0%
18-Nov	44	1	2.3%				4	0	0.0%			
19-Nov	23	0	0.0%	6	0	0.0%	29	0	0.0%			
20-Nov	47	1	2.1%				3	0	0.0%			
21-Nov	63	2	3.2%				7	0	0.0%			
27-Nov										1	0	0.0%
9-Dec				1	0	0.0%						
10-Dec				4	0	0.0%						
11-Dec				2	0	0.0%						
17-Dec	5	0	0.0%	10	0	0.0%						
18-Dec	11	0	0.0%									
IN-SAMPLE TOTAL	687	10	1.5%	1,470	0	0.0%	575	1	0.2%	1,136	1	0.1%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-4. Summary of coho salmon catch samples collected during test fisheries in the Skagit River, 1990.

Sample Date	Area 2 Number Exam.	Area 2 Tags Found[a]	Area 2 % w/Tags (ρ)	Spudhouse Fish Exam.	Spudhouse Tags Found[a]	Spudhouse % w/Tags (ρ)	Blakes Fish Exam.	Blakes Tags Found[a]	Blakes % w/Tags (ρ)	Jetty Fish Exam.	Jetty Tags Found[a]	Jetty % w/Tags (ρ)
August	10	0	0.0%	65	0	0.0%	14	0	0.0%			
4-Sep	5	0	0.0%									
6-Sep				59	0	0.0%	22	0	0.0%			
Subtotal	15	0	0.0%	124	0	0.0%	36	0	0.0%			
10-Sep				59	0	0.0%	21	0	0.0%			
11-Sep	2	0	0.0%									
20-Sep	17	0	0.0%	102	0	0.0%	54	0	0.0%			
26-Sep				83	0	0.0%	53	0	0.0%			
28-Sep	15	0	0.0%									
6-Oct	108	1	0.9%	45	0	0.0%	81	0	0.0%			
9-Oct	165	0	0.0%									
10-Oct				113	0	0.0%	97	0	0.0%			
17-Oct	58	0	0.0%	116	0	0.0%						
18-Oct	51	0	0.0%									
25-Oct	74	0	0.0%	41	0	0.0%	5	0	0.0%			
31-Oct	50	0	0.0%									
1-Nov				11	0	0.0%	16	0	0.0%	3	0	0.0%
8-Nov				3	0	0.0%						
9-Nov							3	0	0.0%			
IN-SAMPLE TOTAL	540	1	0.2%	573	0	0.0%	330	0	0.0%	3	0	0.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-5. Summary of coho salmon escapement samples from the Middle Skagit sub-basin collected during spawning ground surveys by Skagit System Cooperative crews and at a trap on Etach Slough, 1990.

	SURVEYS			ETACH SLOUGH TRAP			SAMPLES COMBINED		
Survey Date	Number Examined	Tags Found[a]	ρ	Number Examined	Tags Found[a]	ρ	Number Examined	Tags Found[a]	ρ
12-Oct				1	0	0.0%	1	0	0.0%
18-Oct	0	0	0.0%				0	0	0.0%
19-Oct	0	0	0.0%				0	0	0.0%
23-Oct	0	0	0.0%				0	0	0.0%
26-Oct				4	1	25.0%	4	1	25.0%
29-Oct				3	0	0.0%	3	0	0.0%
31-Oct	0	0	0.0%	1	0	0.0%	1	0	0.0%
2-Nov	2	0	0.0%	2	0	0.0%	4	0	0.0%
5-Nov				2	0	0.0%	2	0	0.0%
6-Nov	1	0	0.0%	1	0	0.0%	2	0	0.0%
7-Nov	0	0	0.0%				0	0	0.0%
8-Nov	0	0	0.0%	12	0	0.0%	12	0	0.0%
19-Nov	4	0	0.0%				4	0	0.0%
20-Nov	0	0	0.0%				0	0	0.0%
21-Nov	3	0	0.0%				3	0	0.0%
22-Nov	0	0	0.0%				0	0	0.0%
29-Nov	11	0	0.0%				11	0	0.0%
30-Nov	17	0	0.0%				17	0	0.0%
4-Dec	0	0	0.0%				0	0	0.0%
6-Dec	28	0	0.0%				28	0	0.0%
7-Dec	35	0	0.0%				35	0	0.0%
10-Dec	43	1	2.3%				43	1	2.3%
13-Dec	26	0	0.0%				26	0	0.0%
14-Dec	2	0	0.0%				2	0	0.0%
18-Dec	0	0	0.0%				0	0	0.0%
19-Dec	1	0	0.0%				1	0	0.0%
20-Dec	46	0	0.0%				46	0	0.0%
21-Dec	3	0	0.0%				3	0	0.0%
24-Dec	0	0	0.0%				0	0	0.0%
26-Dec	0	0	0.0%				0	0	0.0%
27-Dec	35	1	2.9%				35	1	2.9%
2-Jan	0	0	0.0%				0	0	0.0%
3-Jan	26	0	0.0%				26	0	0.0%
4-Jan	4	0	0.0%				4	0	0.0%
5-Jan				1	0	0.0%	1	0	0.0%
6-Jan				1	0	0.0%	1	0	0.0%
8-Jan	0	0	0.0%	1	0	0.0%	1	0	0.0%
9-Jan	3	0	0.0%				3	0	0.0%
11-Jan				2	0	0.0%	2	0	0.0%
14-Jan				1	0	0.0%	1	0	0.0%
16-Jan				2	0	0.0%	2	0	0.0%
17-Jan	0	0	0.0%				0	0	0.0%
18-Jan	8	0	0.0%	1	0	0.0%	9	0	0.0%
19-Jan				1	0	0.0%	1	0	0.0%
22-Jan	0	0	0.0%				0	0	0.0%
23-Jan	0	0	0.0%	1	0	0.0%	1	0	0.0%
24-Jan	0	0	0.0%				0	0	0.0%
25-Jan	3	0	0.0%				3	0	0.0%
26-Jan	0	0	0.0%	1	0	0.0%	1	0	0.0%
28-Jan	2	0	0.0%				2	0	0.0%
1-Feb	5	0	0.0%				5	0	0.0%
4-Feb	2	0	0.0%				2	0	0.0%
6-Feb	0	0	0.0%				0	0	0.0%
7-Feb	0	0	0.0%				0	0	0.0%
8-Feb	1	0	0.0%				1	0	0.0%
14-Feb	0	0	0.0%				0	0	0.0%
15-Feb	0	0	0.0%				0	0	0.0%
IN-SAMPLE TOTAL	311	2	0.6%	38	1	2.6%	349	3	0.9%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-6. Summary of coho salmon escapement samples from the Upper Skagit sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
1-Oct	0	0	0.0%
31-Oct	0	0	0.0%
6-Nov	0	0	0.0%
20-Nov	14	0	0.0%
21-Nov	2	0	0.0%
27-Nov	0	0	0.0%
28-Nov	0	0	0.0%
29-Nov	4	0	0.0%
30-Nov	7	0	0.0%
5-Dec	19	0	0.0%
6-Dec	1	0	0.0%
7-Dec	0	0	0.0%
10-Dec	3	1	33.3%
11-Dec	1	0	0.0%
12-Dec	15	0	0.0%
14-Dec	0	0	0.0%
20-Dec	6	1	16.7%
21-Dec	2	0	0.0%
26-Dec	0	0	0.0%
27-Dec	3	0	0.0%
28-Dec	3	0	0.0%
2-Jan	11	0	0.0%
4-Jan	0	0	0.0%
7-Jan	11	0	0.0%
11-Jan	12	1	8.3%
14-Jan	2	0	0.0%
16-Jan	12	0	0.0%
17-Jan	1	0	0.0%
18-Jan	7	1	14.3%
24-Jan	15	0	0.0%
25-Jan	15	0	0.0%
29-Jan	10	1	10.0%
30-Jan	19	0	0.0%
31-Jan	6	0	0.0%
1-Feb	5	0	0.0%
7-Feb	9	0	0.0%
8-Feb	7	0	0.0%
13-Feb	2	0	0.0%
20-Feb	1	0	0.0%
7-Mar	5	1	20.0%
IN-SAMPLE TOTAL	230	6	2.6%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-7. Summary of coho salmon escapement samples from the Lower Sauk sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
31-Oct	0	0	0.0%
8-Nov	1	0	0.0%
20-Nov	2	0	0.0%
21-Nov	1	0	0.0%
3-Dec	4	0	0.0%
7-Dec	25	3	12.0%
11-Dec	6	0	0.0%
24-Dec	4	0	0.0%
26-Dec	54	1	1.9%
27-Dec	4	0	0.0%
11-Jan	9	0	0.0%
18-Jan	4	0	0.0%
22-Jan	40	0	0.0%
28-Jan	0	0	0.0%
8-Feb	0	0	0.0%
IN-SAMPLE TOTAL	154	4	2.6%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-8. Summary of coho salmon escapement samples from the Middle Sauk sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
25-Oct	0	0	0.0%
30-Oct	0	0	0.0%
5-Nov	0	0	0.0%
15-Nov	0	0	0.0%
16-Nov	0	0	0.0%
20-Nov	0	0	0.0%
27-Nov	8	0	0.0%
3-Dec	8	0	0.0%
5-Dec	9	0	0.0%
11-Dec	9	0	0.0%
12-Dec	52	0	0.0%
14-Dec	16	1	6.3%
26-Dec	29	1	3.4%
27-Dec	27	0	0.0%
11-Jan	1	0	0.0%
15-Jan	43	1	2.3%
16-Jan	1	0	0.0%
18-Jan	4	0	0.0%
24-Jan	46	0	0.0%
26-Jan	17	0	0.0%
28-Jan	3	0	0.0%
4-Feb	5	0	0.0%
5-Feb	5	1	20.0%
IN-SAMPLE TOTAL	283	4	1.4%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-9. Summary of coho salmon escapement samples from the Upper Sauk sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
20-Nov	0	0	0.0%
7-Dec	3	0	0.0%
17-Dec	0	0	0.0%
28-Dec	6	0	0.0%
21-Jan	0	0	0.0%
22-Jan	0	0	0.0%
IN-SAMPLE TOTAL	9	0	0.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-10. Summary of coho salmon escapement samples from the Suiattle sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
19-Nov	0	0	0.0%
21-Nov	1	0	0.0%
29-Nov	7	0	0.0%
13-Dec	5	0	0.0%
19-Dec	6	0	0.0%
7-Jan	0	0	0.0%
23-Jan	4	0	0.0%
24-Jan	7	0	0.0%
6-Feb	0	0	0.0%
7-Feb	0	0	0.0%
IN-SAMPLE TOTAL	30	0	0.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-11. Summary of coho salmon escapement samples from the Nookachamps sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
23-Oct	0	0	0.0%
24-Oct	1	0	0.0%
5-Nov	0	0	0.0%
6-Nov	1	0	0.0%
19-Nov	4	0	0.0%
21-Nov	0	0	0.0%
28-Nov	1	0	0.0%
5-Dec	21	0	0.0%
6-Dec	10	0	0.0%
12-Dec	0	0	0.0%
13-Dec	4	0	0.0%
14-Dec	3	0	0.0%
17-Dec	0	0	0.0%
19-Dec	9	0	0.0%
20-Dec	0	0	0.0%
21-Dec	0	0	0.0%
26-Dec	4	0	0.0%
2-Jan	11	0	0.0%
3-Jan	0	0	0.0%
4-Jan	4	0	0.0%
8-Jan	0	0	0.0%
10-Jan	0	0	0.0%
28-Jan	0	0	0.0%
IN-SAMPLE TOTAL	73	0	0.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-12. Summary of coho salmon escapement samples from the Carpenter sub-basin collected during spawning ground surveys by Skagit System Cooperative crews and at a trap on Carpenter Creek Slough, 1990.

	SURVEYS			SLOUGH TRAP		
Survey Date	Number Examined	Tags Found[a]	ρ	Number Examined	Tags Found[a]	ρ
28-Oct				11	0	0.0%
29-Oct				3	0	0.0%
30-Oct				3	0	0.0%
2-Nov				1	0	0.0%
5-Nov				5	0	0.0%
6-Nov				2	0	0.0%
7-Nov				1	0	0.0%
8-Nov				3	0	0.0%
21-Nov	0	0	0.0%			
28-Nov	1	0	0.0%			
4-Dec	0	0	0.0%			
7-Dec	2	0	0.0%			
9-Dec	0	0	0.0%			
11-Dec	0	0	0.0%			
13-Dec	0	0	0.0%			
18-Dec	0	0	0.0%			
19-Dec	1	0	0.0%			
20-Dec	0	0	0.0%			
26-Dec	0	0	0.0%			
2-Jan	0	0	0.0%			
8-Jan	0	0	0.0%			
9-Jan	0	0	0.0%			
29-Jan	0	0	0.0%			
IN-SAMPLE TOTAL	4	0	0.0%	29	0	0.0%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-13. Summary of coho salmon escapement samples from the Cascade sub-basin collected during spawning ground surveys by Skagit System Cooperative crews, 1990.

Survey Date	Number of Fish Examined	Number of Tags Found[a]	% with Tags (ρ)
25-Sep	0	0	0.0%
10-Oct	2	0	0.0%
16-Oct	0	0	0.0%
25-Oct	0	0	0.0%
30-Oct	4	0	0.0%
7-Nov	0	0	0.0%
8-Nov	0	0	0.0%
16-Nov	3	0	0.0%
19-Nov	0	0	0.0%
20-Nov	3	1	33.3%
21-Nov	2	0	0.0%
27-Nov	0	0	0.0%
28-Nov	8	0	0.0%
29-Nov	3	0	0.0%
30-Nov	1	0	0.0%
3-Dec	0	0	0.0%
5-Dec	16	0	0.0%
12-Dec	24	0	0.0%
18-Dec	27	0	0.0%
26-Dec	6	0	0.0%
2-Jan	10	0	0.0%
14-Jan	2	0	0.0%
15-Jan	1	0	0.0%
23-Jan	0	0	0.0%
29-Jan	5	0	0.0%
6-Feb	0	0	0.0%
12-Feb	0	0	0.0%
13-Feb	0	0	0.0%
14-Feb	0	0	0.0%
IN-SAMPLE TOTAL	117	1	0.9%

[a] Includes fish recovered with no tag but having the secondary mark (an operculum punch) or having an illegible tag.

Appendix Table A-14. CPUE (catch per beach seine set) of coho salmon bound for major recovery areas in the Skagit River, 1990. CPUE for recovery areas estimated using in-sample tag recoveries.

Recoveries by release strata.

Tag Release Period	Number of Sets	Coho Catch	Catch/ Set	MM Hatchery	Baker R. Trap
1. 01-Sep to 10-Sep	19	29	1.5	5	0
2. 11-Sep to 20-Sep	37	110	3.0	11	6
3. 21-Sep to 30-Sep	33	116	3.5	19	2
4. 01-Oct to 10-Oct	27	209	7.7	25	7
5. 11-Oct to 20-Oct	20	76	3.8	12	0
6. 21-Oct to 30-Oct	34	83	2.4	7	0
7. 31-Oct to 09-Nov	39	63	1.6	2	0
8. 10-Nov to 19-Nov	0	0		0	0
9. 20-Nov to 29-Nov	0	0		0	0
10. 30-Nov to 09-Dec	0	0		0	0
Totals	209	686	3.3	81	15

CPUE of fish bound for indicated recovery areas.

Release Period	MM Hatchery	Baker R. Trap
1	0.26	0.00
2	0.30	0.16
3	0.58	0.06
4	0.93	0.26
5	0.60	0.00
6	0.21	0.00
7	0.05	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00
Totals	2.92	0.48

CPUE standardized as a percentage of total for area.

Release Period	MM Hatchery	Baker R. Trap
1	9.0%	0.0%
2	10.2%	33.6%
3	19.7%	12.6%
4	31.7%	53.8%
5	20.6%	0.0%
6	7.1%	0.0%
7	1.8%	0.0%
8	0.0%	0.0%
9	0.0%	0.0%
10	0.0%	0.0%
Totals	100.0%	100.0%

Appendix Table A-15. Summary of the number of tag releases and number of in-sample tag recoveries by length for male and female coho salmon tagged in the lower Skagit River, 1990.

Length in cm	MALES Number Released	MALES Number Recovered	MALES Percent Recovered	FEMALES Number Released	FEMALES Number Recovered	FEMALES Percent Recovered
35	2	0	0.0%	0	0	0.0%
36	2	0	0.0%	0	0	0.0%
37	0	0	0.0%	0	0	0.0%
38	1	0	0.0%	0	0	0.0%
39	2	0	0.0%	0	0	0.0%
40	10	2	20.0%	0	0	0.0%
41	4	0	0.0%	0	0	0.0%
42	10	1	10.0%	0	0	0.0%
43	9	4	44.4%	1	0	0.0%
44	12	2	16.7%	1	0	0.0%
45	13	2	15.4%	1	0	0.0%
46	20	8	40.0%	0	0	0.0%
47	12	1	8.3%	1	0	0.0%
48	15	5	33.3%	4	2	50.0%
49	21	3	14.3%	8	0	0.0%
50	27	5	18.5%	6	3	50.0%
51	17	3	17.6%	13	5	38.5%
52	12	2	16.7%	12	3	25.0%
53	15	3	20.0%	8	0	0.0%
54	23	6	26.1%	21	1	4.8%
55	11	4	36.4%	17	5	29.4%
56	22	7	31.8%	21	1	4.8%
57	6	2	33.3%	20	4	20.0%
58	12	1	8.3%	17	5	29.4%
59	8	3	37.5%	27	5	18.5%
60	4	1	25.0%	17	3	17.6%
61	19	4	21.1%	14	0	0.0%
62	8	1	12.5%	21	3	14.3%
63	11	3	27.3%	16	1	6.3%
64	12	0	0.0%	10	1	10.0%
65	6	0	0.0%	8	1	12.5%
66	8	0	0.0%	11	1	9.1%
67	8	0	0.0%	5	1	20.0%
68	3	1	33.3%	3	0	0.0%
69	5	0	0.0%	1	0	0.0%
70	3	1	33.3%	2	0	0.0%
71	0	0	0.0%	3	0	0.0%
72	0	0	0.0%	1	0	0.0%
73	3	1	33.3%	1	1	100.0%
74	3	0	0.0%	0	0	0.0%
TOTAL	379	76	20.1%	291	46	15.8%

Appendix Table A-16. Daily summary of the numbers of coho salmon tagged in the lower Skagit River and recovered during in-sample surveys, by sex, release condition, and maturity classification, 1990.

	SEX				CONDITION				MATURITY					
	Male		Female		x-		x		Bright		Blush		Dark	
Date	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.	Rel.	Rec.
7-Sep	9	3	4	1	0	0	13	4	13	4	0	0	0	0
10-Sep	7	1	8	1	0	0	15	2	15	2	0	0	0	0
11-Sep	8	1	2	1	1	0	9	2	10	2	0	0	0	0
14-Sep	22	6	19	2	0	0	41	8	41	8	0	0	0	0
19-Sep	29	5	11	4	0	0	40	9	40	9	0	0	0	0
20-Sep	8	1	6	1	0	0	14	2	14	2	0	0	0	0
21-Sep	18	1	10	0	0	0	28	1	26	1	2	0	0	0
26-Sep	15	5	8	1	0	0	23	6	22	6	1	0	0	0
27-Sep	14	3	17	6	0	0	31	9	31	9	0	0	0	0
28-Sep	21	7	11	1	0	0	32	8	31	8	1	0	0	0
3-Oct	46	7	27	5	0	0	73	12	67	12	6	0	0	0
8-Oct	40	10	17	1	0	0	57	11	55	11	2	0	0	0
9-Oct	47	9	31	6	0	0	78	15	74	14	4	1	0	0
12-Oct	8	3	5	0	0	0	13	3	13	3	0	0	0	0
15-Oct	14	2	7	0	0	0	21	2	19	2	2	0	0	0
19-Oct	24	3	17	4	0	0	41	7	29	5	12	2	0	0
24-Oct	11	2	16	1	0	0	27	3	22	3	5	0	0	0
25-Oct	10	1	28	5	0	0	38	6	31	6	7	0	0	0
29-Oct	2	0	8	1	0	0	10	1	10	1	0	0	0	0
30-Oct	1	1	2	0	0	0	3	1	2	0	1	1	0	0
31-Oct	5	0	3	0	0	0	8	0	5	0	3	0	0	0
5-Nov	7	1	13	2	0	0	20	3	15	1	5	2	0	0
6-Nov	3	1	14	2	0	0	17	3	15	3	2	0	0	0
7-Nov	10	3	7	1	0	0	17	4	11	3	4	1	2	0
Totals	379	76	291	46	1	0	669	122	611	115	57	7	2	0
% Recovered		20.1		15.8		0.0		18.2		18.8		12.3		0.0

Appendix Table A-17. Summary of the estimated number of tags from areas downstream of the tagging area in the lower Skagit River, 1990.

A. Downstream commercial fishery and test fishery catches.

Area	Catch[a] Before Tagging	Catch After Tagging	Number of Fish Examined	Number of Tags Found	Estimated Total Tags Present
8E	0	2,325	928	0	
8	0	1,390	208	1	
78C	0	4,669	1,434	0	
Test Fishery[b]	261	1,367	1,364	1	
78D-1, 78D-2	0	2,659[c]	611	1	
Total	261	12,410	4,545	3	8.2

[a] Catches prior to tagging not included in tag recovery expansions.

[b] Test fisheries at Area 2, Spudhouse, Blakes, and Jetty.

[c] Estimated catch below the tagging area by the commercial fishery after the onset of tagging.

B. Downstream spawning areas (redd data from Conrad et al. 1993).

Area	Estimated Number of Redds	Estimated Number of Fish/Redd	Estimated Total Escapement	Number of Fish Examined	Number of Tags Found	Estimated Total Tags Present
Carpenter	73	2.75	201	33	0	
Nookachamps	414	2.75	1,139	73	0	
Total	487		1,340	106	0	0

C. Out-of-system tag recoveries.

Recovery Area	Number of Fish Examined	Number of Tags Found	Estimated Total Tags Present
Grover's Creek	NA[a]	1	
Total	NA	1	1

[a] Recovery not expanded, tag recovery not part of random sample at the hatchery rack.

APPENDIX B

Details of abundance estimates generated for 1990.

APPENDIX B

RECOVERY LOCATION: Marblemount Hatchery

ESTIMATION METHOD: Petersen

95% CONFIDENCE INTERVAL: Normal Approximation

TAG RELEASE AND RECOVERY SUMMARY:
Number of Tags Released = 670
Number of Fish Examined for Tags = 7,329
Number of Tagged or Marked Fish Recovered = 107

RECOVERY LOCATION: Baker River Trap

ESTIMATION METHOD: Petersen

95% CONFIDENCE INTERVAL: Poisson Approximation

TAG RELEASE AND RECOVERY SUMMARY:
Number of Tags Released = 670
Number of Fish Examined for Tags = 1,382
Number of Tagged or Marked Fish Recovered = 16

RECOVERY LOCATION: Commercial Fishery

ESTIMATION METHOD: Petersen

95% CONFIDENCE INTERVAL: Poisson Approximation

TAG RELEASE AND RECOVERY SUMMARY:
Number of Tags Released = 670
Number of Fish Examined for Tags = 687
Number of Tagged or Marked Fish Recovered = 10

RECOVERY LOCATION: Marblemount – Baker - Commercial Fishery Pooled

ESTIMATION METHOD: Petersen

95% CONFIDENCE INTERVAL: Normal Approximation

TAG RELEASE AND RECOVERY SUMMARY:
Number of Tags Released = 670
Number of Fish Examined for Tags = 9,398
Number of Tagged or Marked Fish Recovered = 133
